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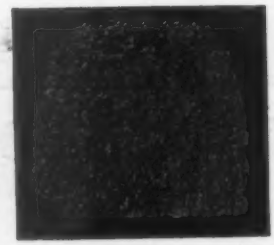
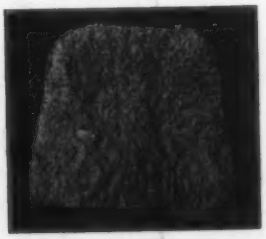

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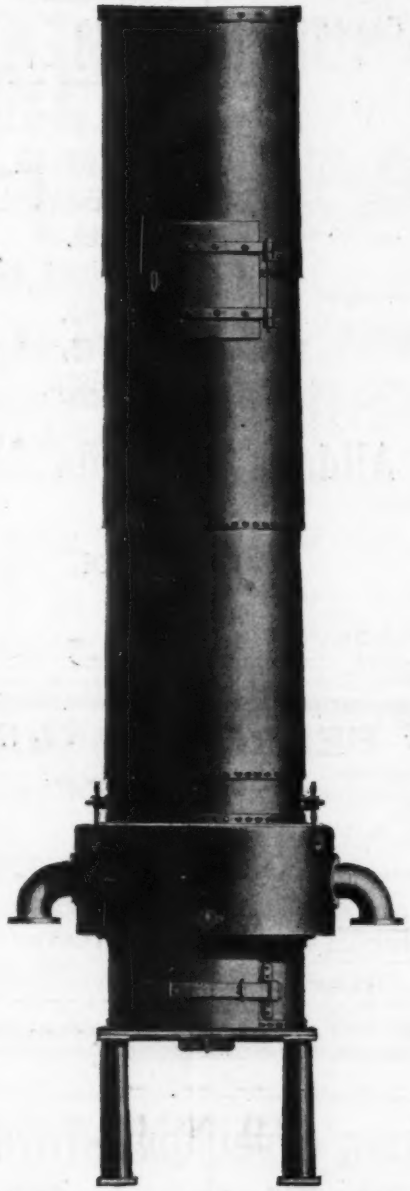

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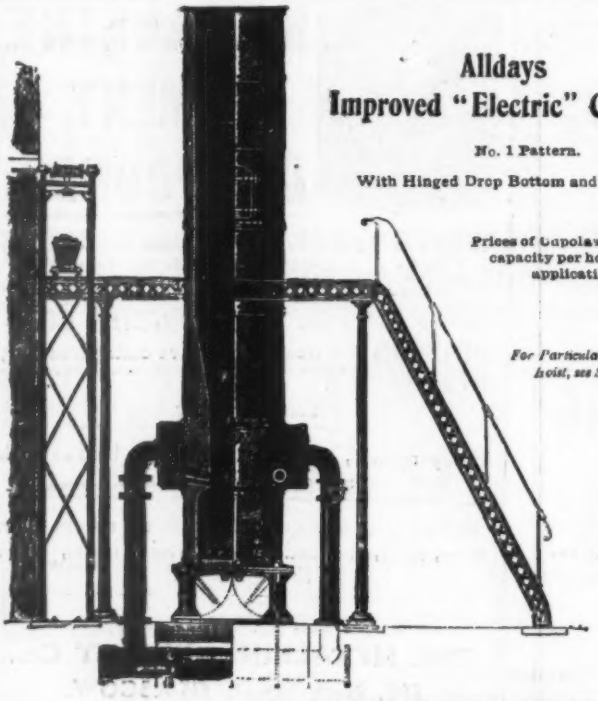

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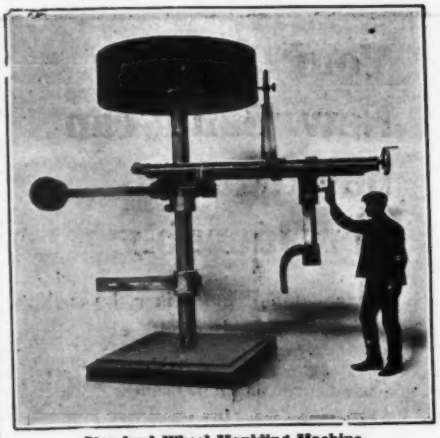

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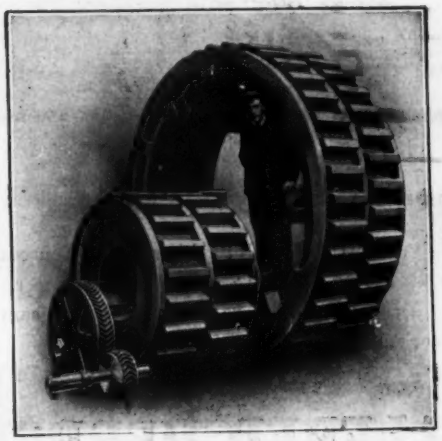

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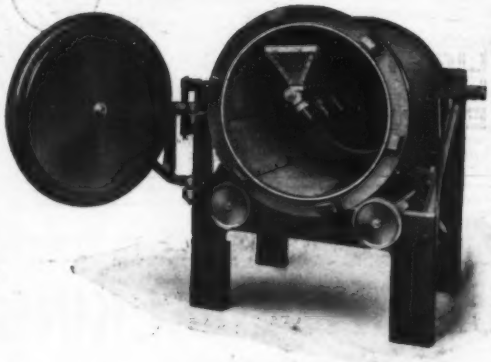

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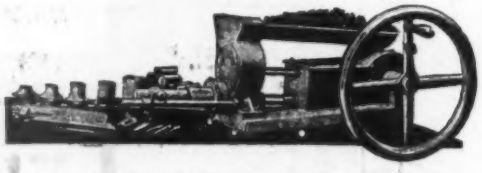

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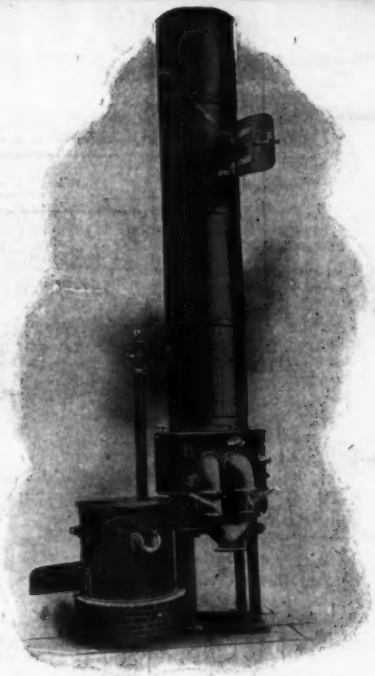

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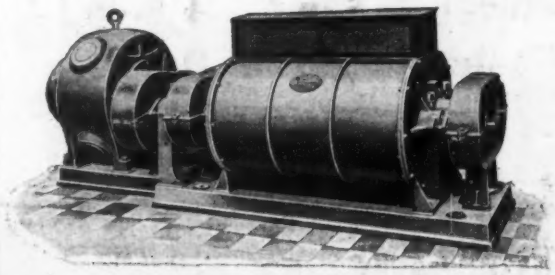

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The Foundry Trade Journal

AND PATTERN-MAKER.

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British Foundrymen's Association (Birmingham Branch).—"Specifications for Foundry Iron," by W. B. Parker, F.I.C.

NOTES AND COMMENTS.

Steel in Cupola Mixtures.

During recent years much controversy has raged around the question of using scrap steel as an addition to the iron charges in the foundry cupola, some users advocating it as a means of obtaining a better grain and higher test results, and others condemning it as productive of hard spots, irregular metal, etc. At the present, however, there is a distinct tendency in many quarters to favour the use of steel for such purposes; and those who have learned to use the material correctly can employ up to 40 per cent. or even more in the charge for some work. There is no doubt that many of the objections raised against the use of steel may be quite discounted, and the failures traced to some cause other than the presence of steel; while the difficulty of melting the steel in the cupola, which has, at times, been raised as a serious objection, does not appear to exist in actual practice. It is interesting, therefore, to enquire as to how steel actually affects the mixture. It has been commonly asserted that one effect is to reduce the carbon content of the mixture, and the use of steel for that purpose was advocated by Mr. Buchanan in a Paper on "Carbon Control in Cast Iron," in which the calculation was based on the total carbon contents of the steel and pig charged, it being assumed that the cupola operation may be regulated so that no carbon is absorbed by the mixture. This feature, however, does not seem to be borne out in actual practice, the mixture absorbing quite a considerable amount of carbon in the cupola; and, in any case, such a low carbon content as would be got with, say, 40 per cent. of steel would not give the easily-machined castings that are produced from the mixture. According to one well-known American user of steel in cupola mixtures, in one instance the estimated total carbon of the material in the charge was only 2 per cent., but when the metal was poured and analysed it was found that the carbon had increased to 3.58 per cent. The silicon in the mixture was low, as also was the sulphur, while manganese was higher than usual; and the castings, of light section, were soft enough for machining. The increase of manganese, of course, may have been largely responsible for the absorption of carbon in this particular case; but it is very unlikely that any mixture which has its total carbon reduced to as low as 2 per cent. by means of steel will pass through the cupola-melting process without absorbing a considerable amount of carbon. Since the carbon content is much below the saturation point, the metal should, while in a semi-molten condition, absorb carbon in the melting zone, by means of contact with the CO there formed; and it is probable that this explains the satisfactory melting of the otherwise difficult steel. In the course of the discussion on the above-mentioned Paper by Mr. Buchanan, it was contended by Mr. J. W. Horne that this absorption of carbon did take place, and not from the solid carbon of the coke but from the carbon mon-oxide generated in the melting zone. This appears highly probable,

and we do not think that in ordinary cupola practice it would be practicable to get the metal down without some such absorption of carbon. It is, of course, difficult to say exactly at what point and in what condition of the metal this carburisation takes place, but it is a process analagous to that of which occurs in case-hardening, except that it is carried out at a much higher temperature and hence much more rapidly.

It may here be asked in what way the fine, so-called "semi-steel" texture of the metal is secured if there is no ultimate reduction of the carbon. The answer to this would appear to lie in the condition in which the absorbed carbon exists. We may here recall the valuable Paper by Mr. Adamson on "Temperature Influences on Carbon and Iron," in which he classed carbon in iron broadly into three divisions:—(1) Finely divided free carbon as found in close fractures of cold-blast grey iron; (2) carbon in an intermediate state between the foregoing and the full-flaked graphite; and (3) the refractory, full-flaked graphite found in No. 1 pig-irons, which is liable to the production of "kish." It is quite feasible that the graphite absorbed at the comparatively low cupola temperature takes largely the form of the finely-divided free carbon characteristic of cold-blast irons; and this would account for the good results obtained with the comparatively high total carbons found with the steel and pig-iron mixtures under discussion. According to Adamson, these three varieties of carbon pass through each stage as a function of time and temperature; and it appears impossible (without chilling) that the carbon in the third-mentioned condition can be destroyed to produce the first-named form without passing through the intermediate form. It will be readily conceived, then, that despite the absorption of carbon in the cupola by these "semi-steel" mixtures, a very different product may be got to that from a hot-blast high-carbon, high-silicon iron.

If the foregoing be accepted as the broad lines upon which steel operates in improving foundry irons, it may also be deduced that the practice sometimes adopted of charging the scrap steel on the bed of coke (presumably in order to ensure melting) is wrong, and is, further, probably the cause of the hard spots sometimes found when steel is used. To charge the steel on top of the pig should give better results and more regular melting. An investigation of the freezing point of the mixture would also probably reveal the fact that the addition of steel, by lowering the silicon and phosphorus in the mixture, raises that point, and prevents the production of the larger graphite which results from a more prolonged setting or solidification. But whatever may be the precise nature of the phenomena occurring when steel is added, the fact remains that such additions are being regularly made in practice with excellent results, including a very considerable increase in the tensile strength of the iron.

The Use of Chills.

Amongst the many innovations which have been introduced into the foundry during recent years, there is probably none that has been so resisted by other departments as the use of "chills," or "chillers," for producing dense and sound parts where weak crystallisation would otherwise be developed during the cooling of the metal. To-day many progressive foundrymen are constantly using chillers in important work, and getting excellent results; but when the knowledge of such practice reaches the machine shop strong protests are raised. Not that the machine shop has by any means frequent cause for complaint (though there are, of course, instances of the careless use of chills causing trouble, as carelessness in almost any direction will); but the term "chiller" is inseparably associated with white iron and the hardness accompanying it, which is so unwelcome in the machine shop. To those who have had experience with such iron under the tool, the machine shop's objection will seem very well based, until it is understood that the use of chillers is not necessarily accompanied by chilled castings, paradoxical as the statement may seem. The trouble lies in the misapplication of the term "chiller," to a device used for performing only part of the function of a true chiller. The functions are the same up to a point; but, while in one case the function is carried on to the production of chilled or white iron, in the other case the effect is limited to hastening the cooling while still retaining a grey iron and its associated softness.

It is fairly well known among foundrymen that the structure of solidifying metal is greatly affected by the rate at which that solidification takes place, the longer the time occupied by the process the coarser the crystallisation. Also, the effects of the protracted cooling in thick sections of a casting adjacent to thin sections are fairly well appreciated; the troubles of shrinkage and porous places in such thick parts are familiar to most foundrymen. With the appreciation of the causes of these troubles there has developed the use of the device known as the "chill," or "chiller," to hasten the cooling in thick parts, though not to the extent of chilling so as to produce white iron; and for this purpose it has proved very efficacious when properly applied. Nevertheless, it is difficult to dissociate the term "chill" from its original function, *i.e.*, the production of a white iron, or iron with a large proportion of the carbon retained in the combined form. In the interests of the foundryman and machine shop alike, therefore, it is highly desirable to adopt a less misleading name for the device employed to assist rapid cooling and the production of a dense structure. The term should convey an adequate idea of the function performed, while, at the same time, limiting the application of the term; and it should convey no misleading impression through previous associations. In view of the function of producing a dense, close structure, we think it will be difficult to find a more suitable term than "densener," and we submit that this should be used in place of the terms "chill," or "chiller." We believe that pig-iron merchants have, at times, applied a similar term to indicate a pig-iron which is supposed to give denseness to a mixture in which it is used; but this should not cause confusion, as the expression does not appear to be a generally accepted one. If ultimately found advisable, the prefix "metallic" densener, could be used to indicate the nature of the device, but "densener" suggests itself as sufficiently comprehensive for the practical man, who is generally averse to long terms. For the latter reason "grey chill," as suggested by some, would have been very suitable, had it not still retained the old association attached to the word chill.

The Functions of a Densener.

The broad functions of a densener have been indicated in the foregoing; but under varying conditions the effects are slightly different. In some cases the chief effect is to create more even cooling and relieve cooling strains; in others simply a denser structure is aimed at; while in others, again, the object is to prevent shrinkage and internal cavities. An extremely practical Paper on the subject, presented before the British Foundrymen's Association, appears on another page of this issue. In the course of the discussion on the Paper it was contended that the use of denseners did not prevent shrinkage defects, but merely re-located them—that the shrinkage holes were still present, but in another spot. In many cases this is correct, for the effect is often to give the desir-

able dense structure to the face (the depth depending on the thickness of the densener), while the shrinkage cavity is still present. But in other cases, where the densener is correctly proportioned to the section of the casting, the defect is quite eliminated. This is particularly frequent when a comparatively slight variation in thickness causes bad crystallisation and perhaps a structure that leaks under test. The defect results merely from unequal cooling and a slight "drawing" of metal from the last part to solidify; and the densener, by equalising the rate of cooling, equalises the structure. In very thick sections, however, where drawn places occur it is difficult to cool sufficiently rapidly to get a dense structure throughout without chilling the outside so as to produce a white iron. It must not be thought that the densener will take the place of proper feeding, though at times it may answer better; its function is to assist cooling so as to give a denser structure of metal in the portions it influences. Properly used, and particularly in conjunction with correct feeding, the use of the densener is invaluable; and at the same time it can be employed to overcome difficulties and defects that cannot readily be combated otherwise.

French Aluminium Industry.

The British Consul at Lyons, in his report for 1911, remarks that the most important development in the electro-metallurgical industry of the district during 1911 related to the production of aluminium and its by-products, the French manufacturers of which have formed themselves into a company called L'Aluminium Francais, with a share and debenture capital amounting to £680,000. The new company has acquired the exclusive rights all over the world in the Serpeck process of aluminium manufacture, hitherto vested in the Nitride Company (Société des Nitrures), who had in 1910 bought up the rights and plant (at Mulhausen) of the Swiss holders of the patent, and had established experimental works in the valley of the Arc, near St. Jean de Maurienne. The Serpeck process, by which the production of nitrates forms part of the manufacture of aluminium, consists in the treatment of bauxite in the electric furnace with air and coke, so as to fix the nitrogen, thus producing a nitride of aluminium. This product is then treated with a solution of caustic soda, which produces aluminate of soda and ammonia gas. From the aluminate of soda is extracted pure alumina, from which aluminium is obtained by the usual electrical process; while the ammonia gas is treated with sulphuric acid and produces sulphate of ammonia. Large works, utilising 40,000 h.p., are about to be established by the Aluminium Combine. The alumina obtained will be used by the various aluminium works grouped together in the new organisation. It is calculated that, given sufficient water-power, the cost of the manufacture of alumina will be reduced, thanks to the by-product of sulphate of ammonia, from £8 to £2 per ton. It is understood that the United States rights have been conceded to a subsidiary company.

The Influence of Phosphorus, Manganese and Zinc on the Physical Properties of Copper.

Writing in "Metallurgie," E. Münker deals with investigations as to the effect of small quantities of phosphorus, manganese and zinc in copper on the tensile strength, hardness, electro-conductivity, and specific gravity. Each of the above elements raised the tensile strength and hardness, and lowered the ductility, electro-conductivity and specific gravity. Phosphorus has the greatest effect on the mechanical properties, followed by zinc and manganese. Their effect on the electro-conductivity is in the order of phosphorus, manganese, and zinc. With unannealed copper phosphorus exerts the greatest influence, followed by zinc and manganese. With annealed copper zinc and manganese have a stronger influence than phosphurus. With all the alloys annealing had the same effect, lowering the tensile strength and hardness and raising the ductility. The changes in the conductivity and specific gravity with heat treatment were very slight.

Annual Dinner of London Foundrymen.

The annual dinner of the London Branch of the British Foundrymen's Association was held on December 14 last, at Holborn Restaurant, London, W.C., when a large number of members and their friends were present. The chair wa staken by Mr. J. W. Horne, B.Sc., the Branch-President.

In proposing the toast of "Scientific Research," the PRESIDENT referred particularly to the research work which had been done at the Technical Colleges in industrial centres, in alloys of non-ferrous metals. Very valuable work had been done at the National Physical Laboratory for the Alloys Research Committee of the Institution of Mechanical Engineers, particularly in the aluminium alloys. The new metallurgical department, the bequest of Sir Julius Werhner, had become a most important centre of research in this direction, the purpose of which research was to increase the knowledge of various alloys, their structure and conditions. The object of all this work was that industry should benefit by the results attained, through applying them in practical operations. If scientific research was to serve its ultimate object it was necessary for the practical and technical men to apply to the best of their ability the information afforded by the scientist. He coupled with the toast the name of Dr. Walter Rosenhain, head of the Metallurgical Department of the National Physical Laboratory, whose efforts had contributed so much to the recent discoveries as to the properties and constitution of alloys.

DR. ROSENHAIN, replying, remarked that the flights of fancy which should govern research were often hampered by considerations of practical utility. If, however, practical utility were given first consideration, the work would be frequently sterilised. In research, the best results often came from work which at the outset was obscurely theoretical. He referred, for example, to Faraday's experiments with electricity and also to the original research from which wireless telegraphy resulted. In conclusion, Dr. Rosenhain put forward a plea for patience with the scientific man, although his work might often be highly theoretical and show little immediate material results. He also asked for the co-operation of the practical workers. There were many problems and phenomena which occurred in practice with which the laboratory worker did not come into contact.

MR. J. ELLIS (Branch-Vice-President) proposed the toast of "The British Foundrymen's Association." He referred to the remarkable growth during the seven years it had been in existence, from 70 to 965 members.

MR. F. J. COOK (a Past-President of the Parent Association), in reply, said that the Association was somewhat unique in its organisation, as it was an institution aiming at the education of the actual workers at the trade. The object was to put founding in all its branches on a scientific basis.

MR. BAGNALL (Member of Council), who also replied, said he considered the Association was equally helpful to the employers. The advancement which the trade was experiencing as the results of the Association's work should be appreciated by every foundry proprietor in the country.

MR. RIDDELL (Member of Council), also replied with a number of amusing anecdotes *apropos* of the foundry trade and other matters.

An excellent musical entertainment was included in the programme, the function being generally voted a great success.

Foundry Sands and their Treatment.

By Algernon Lewin Curtis, M.E.,

(*Continued from page* 738, *December*, 1912.)

The Elements of Sand and their Physical and Chemical Interaction.

The previous chapter was only indicative of the general system of treatment which sands get in the average foundry, and did not favour any particular kind of process, though a complete method will be described in full at the proper place. Moulding sands can be broadly classed as being of two kinds, sands known as "green sand" and "loam," the latter being a ferruginous or calcareous mixture of clay. If loam contains iron, it is ferruginous, if mixed with lime, calcareous. The coal or chalk regions are largely responsible for the supply of good "green said," though the basin of the Thames is considered one of its best sources.

All sands are more or less porous and refractory, though the proper degree of refractoriness can only be determined by exhaustive experiment. Some moulding sands have been found to vary a little in their chemical composition, but generally speaking this cannot be regarded commercially. The percentage of silica in sand varies very considerably; in grey-iron founding it runs from as low as 83 per cent. up to as high as 96 per cent., while for steel work as high as 98 per cent. of silica is used, this being blended with pure Chinese fireclay free from iron oxides. Good moulding sand in its green state should be of a yellowish earthy colour, and be sufficiently fine to take exact impressions of the skin without adhering to it when squeezed in the hand. From 3 to 10 per cent. of natural clay can be found in the new sands, though the average may be placed at about 3 to 6. Most sands contain traces of iron oxide, sometimes as high as 4 per cent., but wherever this is found higher than 2 per cent., it has evidently been introduced into the sand by red or white fireclays, particularly the former. Any oxide of metal in sand is dangerous to the casting of iron or bronze. Lime and magnesia are oftentimes found in small quantities in sands, which on being examined will be found to be too weak or too close. They will not stand or retain their form, or will cause the metal to boil in the mould by their closeness.

The different classes of castings required in practice necessitate different kinds of sand. One class of castings demands sand that is porous and open, but still adhesive, while for another class it must be very fine, free from grit, and also very adhesive. Alluvial deposits of metamorphous rocks, such as slate or felspar, make a superior moulding sand, if they do not contain much iron; but in volcanic regions great difficulty is experienced on account of the limestone. Sands which contain iron, lime, or particularly mica, will not adhere, and are liable to absorb and retain too much moisture, thus causing rough and unsound castings.

The composition of moulding sand may appear to be most simple at first sight, yet many difficulties and failures are encountered in foundries every day. It is of the utmost importance in the foundry that the correct composition of moulding sand be obtained, and once the proper mixture has been arrived at, it should be duplicated as often as possible. When sand contains a large amount of clay, it is too "strong" for anything but small or thin castings. Sand of this character should be used as dry as possible, as it will absorb great quantities of water without altering its appearance, and then be found to be too damp for casting. Continual use or burning will improve it, or a judicious admixture of coal, charcoal or coke dust will help to neutralise the clay. Too much coal dust, however, is apt to make the castings rough, and great care should be exercised in this respect. Such strong sand ought, therefore, to be avoided for heavy work, as the heavier the cast, the coarser the sand should be. Fine sand will cause the same trouble as coarse if it contains a lot of clay, especially if this occurs in patches.

Mixed with charcoal dust, fine sand makes excellent moulds, when properly blended, but should never be used on heavy work. The action of a large mass of molten metal in moist sand is to generate a quantity of steam, which requires vent, and any sand containing an excess of clay or compound will prevent the steam from escaping. For mixing purposes the value of old sand has only just begun to be appreciated in the foundry, as it is the only material that can be termed reliabily consistent. Freed of its impurities in the form of vegetable and organic substances, it makes an admirable material to use when the proper bond is introduced into it. As an illustration of the value of old sand to the founder, the author knows of an instance where equal quantities of old sand and new silica sand were successfully bonded with 5 per cent. of Chinese fireclay for making steel castings.

It is stated that no two moulders can ram alike as regards pressure, and as there are thousands of castings requiring the same mould density or sand pressure, it is a wonder there are not more spoilt castings; for, after all, the value of a mould depends upon the correct pressure or density to which it is rammed, other things being equal. Such an effect can only be produced by the sand being subjected to the proper pressure, and without the knowledge of this pressure, it is very difficult to arrive at the correct sand mixture with which to make the mould. In the diagnosis of any sand mixture, tensile and transverse strengths must be determined, which can be done by proper instruments, and the author has one in the course of preparation to determine the pressure of sand in any given mould, which will show in pounds and ounces per square inch the actual resisting capacity of any part of a given mould.

To enable the reader to follow more closely the above, perhaps some illustration is desirable. Suppose a founder has a large number of castings of about the same size and calibre. In the course of the work several moulders will be employed, and each moulder will ram his mould at a different pressure or density; while experience proves that the best workman will get the largest number of good, clean castings. If this man's moulds are checked, and the pressures noted, allowing him to use his own judgment at first, as to what he considers the right pressure or strength to ram each mould, when the pressures are compared with those of an inferior workman, it will be found that the difference between a good and bad moulder, on the same kind of mould, is several pounds per square inch. This difference would not be so magnified if

the sand mixture were uniform, but as many moulding sands contain batches of clay, and others no clay at all in parts, even a good workman is handicapped, because he may be ramming up sand which in parts is too strong, and which stops venting. Having found the necessary pressure which a mould should be rammed to obtain a sound casting, it then remains for this data to be used as a base for making a duplicate sand mixture. A sample of sand taken from the heap from which the mould was made, is subjected to the same pressure in the form of a round core, and then tested for tensile and transverse strengths. If such sands are unmixed, weak, strong, patchy or unsuitable, some extraordinary results will be recorded; and if samples of sands that have been cut over or treated in a pan mill are tested by these means, it is scarcely possible to get the breaking strain of one sample within 50 per cent. of another, both samples being taken from the same heap. As a further check, condemned moulds can be cast, and results will show the efficacy of the tests. Tensile and transverse figures having been established, it only remains to utilise as much old waste sand with new as will show on the test pieces the desired strength; then considerable economy can be effected by this method in sand alone.

When it is considered that in almost every kind of material used for constructional purposes some system is adopted for testing, not only for their chemical constituents, but also for their physical qualities, it cannot be claimed as unreasonable or impractical if the same principles are applied to core and moulding sands. For physical qualities such simple tests as "squeezing" for fracture and adhesiveness, examination under a magnifying glass for "texture," pouring water on the sand to determine its "porosity," and the overlapping method for "breaking strain," will answer if the product is uniform and homogeneous; but none of these tests will show the difference between two samples from the same heap, one containing an excess of clay and the other a shortage of the same material.

The correct proportions of different sand mixtures is too exhaustive a subject to treat even briefly at this point, as different practices and conditions make it scarcely possible to lay down any hard and fast rules. One fact, however, can be stated—any sand mixture which has been properly treated, will require less new sand, or compound, and be more reliable, than one which has only been turned over once or twice, or mixed in a pan mill or concrete mixer. It has been stated that two parts of old sand to one of new will make a good "floor mixture," with coal dust added equal to one quarter of the sand volume. Such a sand mixture is unnecessary; in fact, the trouble of working out the correct proportions for a facing mixture is only superfluous work, when a standard mixture of the quality of facing sand can be obtained always by means of an efficient plant.

Some authorities prescribe equal quantities, or three of old to two of new sand for facings, with half a part of coal dust. They do not say whether such proportions should be specially mixed or not, so the conclusion to be drawn is that they receive just the common treatment. Assuming that either 1 to 1, or 3 to 2, are proportions used in practice, then it is an expensive way of prescribing a sand mixture; as 3 to 1 will give better results if mixed in a "batch mixer," while 10 to 25 parts of new sand added to 100 parts of old, will, if well kneaded in an efficient plant, give better results than are obtained in a mixer of he batch type. The reason why, under present conditions, an excess of burnt or old sand cakes when used again, making the metal boil, is because in some cases it has been ground, while in others no matrix of clay for holding the particles of silica has been formed by kneading.

A useful practical rule for testing the strength and necessary degree of dampness in any sand mixture, is to make cores 12 in. long by 1 in. square, and push each core or test piece over the edge of a smooth surface until it breaks by its overhanging weight. The following figures will show the strength of sand mixtures which have been inefficiently treated, compounds being used. A test piece 12 in. long, by 1 in. square, of old sand, will break when about 1 to 1½ in. overhangs. The same size test piece of new sand will average from 2 to 3 in. before breaking, and in a sand mixture prepared with coal dust from 1 to 2 in. will cause a break. Properly treated sand mixtures, containing less new sand than used in the aforementioned test pieces, will never show less than 4 in., and go as high as 6 in. before breaking. This is due to the particles of silica being so evenly embedded in a matrix of clay that the shear is uniform and even.

Before concluding this side of the subject, it is necessary to refer to the "tempering" of sands, which, in other words, represents the amount of water necessary to mix with a sand to make it keep its shape, and allow the moulder to finish his work on it. It should always be borne in mind that tempered sand can be rammed about twice as close as the same sand when thoroughly dry, as the density of the sand is affected by wetting, so that unless properly rammed it will not come back to its proper character. The "tempering" of sand is more or less under the control of the moulder, provided there are in his material no patches of clay, which will always cause trouble. Every moulder knows that damp sand means steam, so except for a light layer of facing, the underneath strata should be as dry as possible, to allow vent holes to "live." The facts that sand in a mould must be strong or dense enough to resist a head of molten metal, and that hot lively metal will not remain long on wet dense sand, speak for themselves, and require no further explanation.

It is proposed later to show why sands should be treated, and to give processes of treatment which are automatic or continuous, so that instead of sand mixtures being for their essential purposes uncertain quantities, they can be made to suit any kind of work. The subject of "Core Sands" has been particularly left alone for the present, as its different ramifications are too many, and of too great importance to be touched upon with brevity. That subject will receive full consideration later. Suffice to state that core-sand mixtures cannot be "tinkered" with, and ought to be treated more accurately than any of the others, especially for stove-plate or crucible-steel work. Many founders are using entirely new sand with quantities of compound, when better cores can be made of old sand with the right kind of clay if properly treated. One firm in America is using 90 per cent. of old sand for their cores, bonding same with a particular form of clay and treating the whole in a plant designed for its special use.

The Selection of Moulding Sands for Castings.

The selection of good sand mixtures for making high-grade clean castings in brass, iron or steel, which not only have to pass severe tests, but be possessed of a skin that requires little "faking" and be true to shape, is often a source of great trouble to the average founder. No doubt if a sand merchant had worked as a moulder in a particular foundry, he would be able to advise whether his particular grade of sand would mix with advantage with the other materials; but as these instances are rare, the

founder is dependent for his supply on a merchant whose material may be excellent, but whose knowledge of sand is more or less confined to his own products, and does not necessarily embrace the special characteristics shown by materials taken from different parts of the country.

Perhaps the first step in selecting a sand mixture is to ascertain its work, and in this connection it is necessary to go back to that part of the study of iron and steel which deals with the gases in the metal. Compared with the volume of metal, the volume of gas is estimated as being 65 per cent. for Bessemer steel (without "spiegel") and 35 per cent. for pig-iron, the component parts being hydrogen 83.3, nitrogen 14.2, and carbonic acid 2.5.

Experiments were conducted on the following lines. An ingot or casting 2 in. in diameter was cooled in water, after which it was coated with wax, and drilled while still warm under water, the gases being collected in the inverted hole. Some doubt was caused by the above figures at first, so further experiments were made substituting oil for water, but the results did not differ much. Fresh tests were made by Graham, however, who tested iron samples in vacuo and was engaged pumping out the gases for some considerable time. He found that hydrogen was the first, and also the most easy gas to be obtained, the next being carbonic oxide. After working on a sample of iron for two hours Graham's figures were hydrogen 35 per cent., nitrogen 7 per cent., carbonic oxide 50.3 per cent., carbonic acid 7.7 per cent., and further work on the test piece revealed hydrogen 21 per cent., nitrogen 21 per cent., carbonic oxide 58 per cent., with no carbonic acid.

If these figures show the state of iron or steel in its almost normal condition, the phenomena of gases created by the same materials in their molten condition introduces a problem of no little importance to foundrymen, and great care should be paid to not only the actual volume of gases, but their component parts, while care should be taken to avoid the addition of any organic substance in the form of core compounds. These latter will complicate the matter by their liability to form further gases. Metallurgical chemists in foundries could make some interesting experiments and, besides, provide useful data, by determining the pressure and components of these gases escaping from moulds which have in their composition an excess of organic substances.

Sand in which molten metal is run for the purpose of casting should be sufficiently cohesive to accurately receive and retain the form of the pattern, besides being fit to be rammed at such density as will resist the pressure of the head of metal and prevent the permeation of the latter through, and this without interfering with the escape of gases given off from the metal, sand, compounds and blacking. This sand should not be affected chemically, neither should it fuse by reason of the heat from the metals, and besides giving a clean, sharp, smooth surface to the casting, it ought to part readily from it when the latter is cooled. Sands of this character are usually found in the Coal Measures, or in the New Red Sandstone of Shropshire, Cheshire, Derbyshire and Nottinghamshire, the Basin of London, Lanarkshire in Scotland, and the North of Ireland. For common grey-iron work 1 to 7 per cent. of coal dust is generally mixed with these sands, and tempered to the required degree.

Knowledge of refractory materials in the foundry and steel works is a valuable adjunct to those engaged in the process of making castings, as an inferior sand can be utilised if treated properly by an admixture of the correct material. It is not heat which destroys a mould or core, neither the intensity, or the caloric quality, but the chemical affinity of the molten metal for the material of which the mould or core is made. Both silica and alumina are practically infusible, whether single or combined, though if combined with potash or soda they can be readily melted. Magnesia and lime form more or less fusible compounds with silica or clay, though they cannot be fused together with potash or soda. The same with oxides of iron or manganese; they will easily melt with silica or alumina, but not with potash or soda.

The above-mentioned principles are those which govern the base of a refractory material, so it is evident that if lime, magnesia, potash or soda are fused in contact with silica the latter will be dissolved in proportion to the amount of potash, the intensity of heat, and the length of time for which they are exposed. Where the amount of potash is small a proportionately less amount of silica will be dissolved, as affinity increases with the predominating element.

Intensity of heat, and time, can be interpreted as being two different agencies, possessing different qualities. What time cannot accomplish heat will effect, while a deficiency in heat will be compensated for by time.

The most refractory materials at the disposal of the foundryman are silica, clay, magnesia, lime and the silicates of the four alkalies, of which the silicates of alumina rank first, and those of magnesia and lime next. Fireclay can be classed as being in the first, soapstone in the second, and impure lime in the third category. One thing should be remembered in preparing a refractory material, and that is, any mixture containing more than two elements is more fusible than a compound containing only two; in other words, the degree of fusibility increases with the increase in the number of elements.

Common clays used for bonding sand are refractory in proportion to their basic nature, which is, to the alumina that is contained in them, and are less useful as fireclays as they become more acid in their character. Such clays cannot reasonably be used in their raw state; they require admixtures of other ingredients, together with an efficient mechanical treatment, though if such clays are properly treated in conjunction with silica, or the various components of a correct sand mixture, no preliminary treatment of the clay is required. Clays contained in sand, of whatever character, if not mechanically treated, will contract in volume and crack when exposed to a high temperature, causing fissures and depressions, which quickly destroy the mould or core in which they occur. The degree of plasticity of any clay is its capacity to be moulded into any required form without loss of cohesion. This degree is governed to a certain extent by the amount of chemically combined water and alumina the clay contains, also the structure of its particles, the finer the clay the more plastic its character. In analysing clays, or determining clays in sands, the hygroscopic water can be expelled by heating the samples to 100 deg. C., or 212 deg. Fah., without in any way destroying their plastic nature. A higher temperature, however, will expel the combined water, after which clay loses all is plasticity, which it will not recover, although its affinity for water is as great as before. From 1 to 2 per cent. of alkali will render clays fusible at high temperatures, and lime or magnesia, even in much smaller quantities, will make most clays comparatively fusible. The difference between common clays and fireclay is that the latter, being a hydrated aluminous silicate, will stand greater exposure at high temperatures without softening or melting, and its value depends upon the

freedom from calcic carbonates, iron pyrites, and ferrous oxide, either of which will easily combine with the silica of the clay, forming readily fusible vitreous silicates.

Three to four per cent. of foreign oxide in a silicious clay will render it fusible, though if a clay be of an aluminous character a larger amount of ferrous oxide will not destroy its refractory quality; hence 1 per cent. of alkali or upwards in a fireclay may injure its qualities. Iron oxide has a strong fluxing effect, and anything over 1 per cent. will affect the fusibility of the clay, though if alkalies be absent its action is much more limited. Clays taken from the same regions, and presenting the same appearance, are, when analysed, found to differ widely in their degree of fusibility, which may arise from the influence of free silica, or the substitution of one metallic oxide for another.

The power of clays to resist heat is influenced by the molecular action of their particles, by the organic matter contained, and by the *mechanical arrangement of these particles*, (more so in a moulding sand than a clay, as the secret of a moulding sand is the mechanical arrangement of its whole structure). In most cases the coarser the particles, the more refractory the material.

Sand and loam for cores and moulds are apt to vary very considerably in quality, so it should be the business of the foundryman, when selecting these materials, to establish a minimum of variation. It is generally believed that by squeezing a handful of sand, a fair diagnosis can be arrived at of its bonding qualities. In this the operator may be misled, as it is quite possible to fake a sand mixture which will successfully stand this test in the hands of an experienced man, and yet cause such cutting and scabbing that the castings are spoiled. Analysis by persons accustomed to determining the chemical qualities of sands and who are also handling the same in foundries every day will reveal much that is at present kept in the dark. By determining the percentages of combined water, the amount of clay can be calculated: also, the degree of fusion can be ascertained by finding the percentages of oxide of iron and lime.

One point in connection with moulding and core sand that has escaped the notice and attention of the foundryman, is the scientific and microscopic examination and classification of the texture or range of fineness of the sand particles. Several individuals have endeavoured to form a standard of sands, after determining their fineness by sieves or screens, none of which standards have as yet been adopted commercially. Of course, it is well known that the finest stove-plate sands are the zero of fineness, and that for heavy work it is considered good practice to use sand having particles as large as possible; but for the intermediate stages of work it is difficult for the average foundryman to prescribe a sand mixture of a certain grade of fineness, because little is known of its action in this direction. Any objection foundrymen may offer to the experimental uses of different grades of fineness can only be based on the fact that sands used in this respect have not had their particles controlled and made uniform by proper mechanical treatment, as a sand mixture may be fine in parts and coarse in others. This is illustrated by sands ground in wet or dry pan mills or concrete mixers. If the founder wants fine sand, let him order it in the form ground by nature, but not go to the expense of grinding it. If a coarser sand is desired there are many natural banks which contain such material. At all events, a coarse and fine sand mixed together will not make moulds or cores fit to turn out high-grade castings, as the fine sand will let down the coarse, or the reverse; and no treatment known can make a suitable mixture of two materials so opposed to each other in shape. Attention should also be paid to the coal dust which is added to sands, as a poor coal dust can cause a lot of trouble. Any coal dust containing over 5 per cent. of moisture or 10 per cent. of ash should not be used.

The next important point in the examination of moulding sands is a simple method of analysing them. To the average founder who does not possess a well-equipped chemical laboratory, a simple though effective set of apparatus can be obtained, and used to determine nearly all that is necessary. A correct analysis, however, will not help to put matters right, unless the other various points of treatment are complied with. In other words, a founder may be having all sorts of trouble in his foundry, and he may make an analysis of the sands and find in the sand mixture too much clay or too much iron. The sand can be rejected, but the trouble may still remain, and the only way to get rid of this trouble is by finding a material up to a standard determined by analysis, and then assuring control of its particles by the means of an efficient plant.

To analyse a sample of sand, first grind about 1 gramme of the material, and pass same through a sieve of 100 mesh. Then dry same for an hour at 100 Cent., (212 Fah.) to expel the hygroscopic water, moisten the sample with about 5 cubic centimetres water, then add 15 c.c. H_2SO_4 at 1.84 sp. Have the mixture stirred well, cover with a watch glass, and digest on the hot plate for 12 hours at a temperature high enough to make the acid fume; remove the beaker which contains the sample, allow it to cool, and dilute with 100 c.c. cold water. Stir thoroughly, bring to a boil, and filter through a close filter, using No. 589 blue ribbon, then wash well with hot water. Discard the filtrate, and replace paper and residue in the beaker, digesting with 100 c.c. of 10 per cent. NaOH solution for 30 minutes at boiling temperature; filter again through a close filter, washing by decantation three times with 1 per cent. NaOH solution, leaving the bulk of the filter paper and the residue in the beaker. To this add 50 c.c. hot 1 to 3 HCl., stir thoroughly, then continue the filtration and transfer the contents of the beaker to the filter. Keep on washing with hot water until the washings are free from chlorides. Burn the residue wet in a weighed platinum crucible, and ignite to constant weight. The weight obtained is the weight of the quartz plus felspar. This weight subtracted from 1 gramme gives the weight of the clay substance in the sample. Fuse this quartz-plus-feldspar residue with five times its weight of Na_2CO_3 in the platinum crucible and determine the alumina present. This is the alumina of the feldspar. Calculate the weight of the felspar, subtract it from the weight of the quartz-plus-felspar, and obtain the weight of the quartz. Felspar :—At. 2.02, $K_2O.6SiO_2$ equals 18.34 per cent. At. 203. To obtain the approximate ultimate analysis of the sand, instead of discarding this filtrate containing the sulphuric acid solution of the iron and alumina of the clay substance, oxidise it with bromine, precipitate the iron and alumina with ammonia and determine their respective weights, using these two additional results together with the analysis and the formula given below, to calculate the ultimate composition. Total silica equals the per cent. quartz plus 64.74 per cent. felspar plus 46.51 per cent. (clay substance minus iron oxide). Total alumina equals the alumina of the clay substance plus the alumina of the feldspar. Total iron oxide equals the iron oxide of the clay substance. Total alkali equals 16.9 per cent. of the felspar.

(To be continued.)

Metallurgical Control in the Brass Foundry.

By H. S. Primrose.

The second meeting of the Scottish Branch of the British Foundrymen's Association this session, was held on Saturday afternoon, November 9, in the Royal Technical College, Glasgow, when the President, Mr. Wm. Mayer, of Dumbarton, occupied the chair. In calling upon Mr. Primrose to read his Paper upon "Metallurgical Control in the Brass Foundry," MR. MAYER said he welcomed a change in the subject of their papers, which had hitherto been chiefly concerned with iron-founding. He considered that the more diversified their lectures were the more would their members be kept interested in the various aspects of founding different metals.

MR. PRIMROSE pointed out at the outset the various difficulties which the brass-founder had to position, physical tests, and microstructures as well.

By the aid of a large selection of lantern slides, the lecturer illustrated the arrangement of the gunmetal foundry of Messrs. G. & J. Weir, Limited, of Cathcart, where he is engaged as chief metallurgist. The roof of the foundry is over 30 ft. from the floor, and is copiously provided with ventilators. It is also well glazed to give ample roof light for efficient moulding practice. The moulding shop is largely fitted with moulding machines; extensive stove accommodation is provided for drying the moulds, and the cleaning is mostly accomplished by means of compressed air. Both electric and hydraulic power is supplied to the numerous cranes in all the bays,

FIG. 1.—BAY IN GUNMETAL FOUNDRY; WORKS OF MESSRS. G. & J. WEIR, LIMITED, CATHCART, GLASGOW.

face which were not met with in ironfounding practice, the chief being the trouble due to melting in small quantities which suffered considerable loss by oxidation, and which frequently gave off poisonous fumes. Zinc was the worst offender in this respect, giving rise to the fine white flakes of oxide known as "philosopher's wool," which when inhaled continuously induced an incurable disease known as brass-founders' ague. To obviate this risk as far as possible, modern brass-foundries were designed to give ample lighting and ventilation, and the health of the workmen was further safeguarded by suitable sanitary arrangements. Other essentials in the attainment of high efficiency in the foundry were stated to be a systematic lay-out of the plant to enable the metal to pass through the shops in a straightforward direction, and a complete scientific control of all the raw materials used. The metal itself should also be traced through all the stages of its treatment, and records kept of its chemical com-

and a narrow-gauge railway is found very convenient throughout the shops. Details were given of present practice in making up charges from analysis, and melting these both in crucible and air furnaces, and Mr. Primrose further described the recent advances made in melting by the introduction in many works of various forms of tilting furnaces. Oil-firing appeared to possess the greatest number of advantages at the moment, but in the near future he considered it probable that electric arc and induction furnaces would be largely utilised for melting non-ferrous metals and alloys, their great advantage being the almost complete exclusion of air from the metal, which is thus protected from burning or excessive volatilisation loss.

After describing the various chemical and physical standards to which the castings must conform, Mr. Primrose discussed the structure occurring in normally cooled gunmetal as revealed by the microscope, and indicated how irregularities were de-

tected and how the cause of various types of faults could be determined and removed. Surface cavities were shown to be due, as a rule, to moulding defects, the metal being restored to a sound condition by simple remelting. In the case of oxide inclusions, however, it was recommended to add some deoxidising agent, such as phosphor-copper, to produce perfectly restored material on remelting. Slides were shown to illustrate the arrangement of the various micro-constituents of good gunmetal, and several examples of weakening of the metal were shown to be due to segregation of the hard eutectic of copper and tin, which had prevented the proper growth and interlocking of the crystals of the chief constituent, rich in copper. The contrast is shown by the illustrations, Figs. 2 and 3. The great value of the microscopical examination was clearly shown from the several examples, as a most accurate method of controlling the metal.

FIG. 2.—STRONG GUNMETAL STRUCTURE; SHOWING ISOLATED EUTECTIC AREAS; MAG. 60 DIAMS.

FIG. 3.—BRITTLE GUNMETAL STRUCTURE; SHOWING CONTINUOUS EUTECTIC MESHWORK. MAG. 90 DIAMS.

Discussion.

In the discussion which followed, MR. BELL wished to know what was the composition of gunmetal, as there were now so many varieties of it on the market; also, if the addition of zinc was necessary, and what was the amount allowable?

In reply to this MR. PRIMROSE said that true gunmetal was a bronze alloy containing 90 per cent. of copper and 10 per cent. of tin, but that the specification of Admiralty gunmetal as described in his Paper, was 88 per cent. copper, 10 per cent. tin, and 2 per cent. of zinc. This small quantity of zinc was all that was required to keep the metal sound under ordinary conditions, and quite free from blowholes.

MR. WILLIAMSON asked a question about the blowholes occurring in gunmetal castings, desiring to know how to distinguish between steam-holes and gas-holes. He also asked a question about the best type of oil-fired furnace to use for melting up to 20 cwts. of metal. Replying to this Mr. Primrose stated that almost invariably the steam-holes were found in the metal near the surface, and were accompanied by a structure in the alloy similar to that got on casting in a chill mould instead of sand. The gas-holes were generally deep-seated, and the structure of the surrounding metal was quite normal, but, of course, seriously weakened by the presence of the cavities left by the gas. He knew a new type of furnace for handling melts of 6 cwts, in a tilting form, but he was unaware of any form at present made large enough to deal with 20 cwts. at once.

Another speaker thought it would not be possible to mix to analysis, say, in melting a true brass with 40 per cent. of zinc, where the loss was very heavy, often up to 10 per cent. of the spelter, and the usual method of testing a sample by fracture was defended as the only satisfactory means of judging when the proper composition was reached. Mr. Primrose replied that if the loss of zinc by volatilisation were determined by a series of experiments under the ordinary melting conditions, the charge could be calculated and the proper allowance made for loss, so as to strike the required composition more nearly than the common method of trial by examining the fracture.

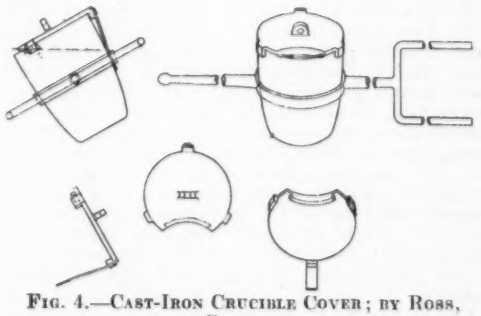


FIG. 4.—CAST-IRON CRUCIBLE COVER; BY ROSS, GLASGOW.

Further details were desired of the detachable cover for the small crucibles as described by Mr. Primrose, and designed to prevent the fumes from the hot metal inconveniencing the workmen during the pouring into moulds. These details were given.

and also a sketch shown to illustrate how the metal was also skimmed by a small lip projecting from the top of the metal cover into the metal at the pouring spout. This sketch is here reproduced in Fig. 4.

The PRESIDENT asked the lecturer if he could tell them more about the pyrometric control of the casting temperature of the metal, and if there was a simple form of optical pyrometer that a foundryman could use without a scientific training.

MR. PRIMROSE then described the use of the platinum thermo-couple, which was rather slow in reading when suitably protected against the corrosive action of alloys containing zinc. Several simple optical pyrometers were made and could be used under certain conditions, but not readily with bronzes and brass, since it was extremely difficult, if not impossible, to get a view of the metal surface entirely free from oxide scum which formed almost immediately after each skimming.

On the motion of MR. M. RIDDLE, Mr. Primrose was accorded a very hearty vote of thanks for his Paper and the excellent lantern slides he had made to illustrate it.

Liquid Fuel in the Foundry.*

BY W. N. BEST.

There are two kinds of petroleum, one having a paraffin base, the other an asphaltum base. Either may be used as fuel in its crude state, but both are largely distilled to obtain the more volatile oils, such as gasoline, benzine, kerosene, etc. The residuum is called fuel oil, and is used in every class of service where coal, coke, or gas, can be used. It is proving a desirable fuel, because the operator has the fire under perfect control, and can attain and maintain the heat required at all times.

The ultimate analysis of this oil is as follows:—Carbon, 84.35 per cent.; hydrogen, 11.33 per cent.; oxygen, 2.82 per cent.; nitrogen, 0.60 per cent.; sulphur, 0.90 per cent. Gravity, from 26 to 28 Baume; weight per gallon, 7.3 lbs.; calorific value varies from 18,350 to 19,348 B.T.U. per lb.; vapourising point, 130 deg. Fah.

Analysis of Texas oil:—Carbon, 84.60 per cent.; hydrogen, 10.90 per cent.; sulphur, 1.63 per cent.; oxygen, 2.87 per cent. Gravity, 21 Baume; weight per gallon, 7.5 lbs.; calorific value, 19,060 B.T.U. per lb.; vapourising point, 142 deg. Fah.

Analysis of California oil:—Carbon, 81.52 per cent.; hydrogen, 11.01 per cent.; sulphur, 0.55 per cent.; nitrogen and oxygen, 6.92 per cent. Gravity varies from 12 to 36 Baume; weight per gallon, 7.6 lbs.; calorific value varies from 18,462 to 20,680 B.T.U. per lb.; vapourising point, 230 deg. Fah.

Oil tar is a by-product of the water gas system used in numerous gas works. Coal tar is a by-product of coke ovens. When either of these tars is heated sufficiently to reduce its viscosity, it is excellent fuel. Per pound their calorific value is less than that of oil, but as they weigh from 9½ to 10 lbs. per gallon, while fuel oil only weighs 7.3 lbs. per gallon, their calorific value per gallon is greater than that of fuel oil. Oil tar has a calorific value of 16,970 B.T.U. per lb. or 161,200 B.T.U. per gallon, while that of coal tar is 16,260 B.T.U. per lb. or 162,600 B.T.U. per gallon.

In burning liquid fuel it is essential to have good refractory material. It is first necessary to have a burner scientifically constructed, that will atomise any gravity of liquid fuel purchasable in the open market, no matter whether the oil be volatile or heavy. The burner should be of such construction that it will not carbonise, but will attain and maintain the required temperature at the will of the operator. It also should be of such construction that when applied to a furnace, mould-drying or core-drying oven, it will fit the fire chamber perfectly. Without cutting away the fire-brick, it must deliver the flame and heat uniformly throughout the length and width of the fire chamber.

In applying liquid fuel to any equipment, it is essential to know, first, the capacity of the burner and, second, whether it is necessary to have the burner filed to spread a blanket of flame which will cover the entire hearth or charging space of the furnace.

The great difficulty in burning liquid fuel is that many of the burners do not thoroughly atomise the oil, and they are of such construction that they carbonise. Furthermore, the burners are not carefully adapted to the type of furnace or oven to which they are to be applied. Some burners may operate fairly well with a light fuel, but when heavy fuel is to be used, they do not thoroughly atomise the oil.

A combustion chamber of adequate form and proportions for uniting the air with the atomised fuel before it reaches the furnace proper, should be used on every furnace. This prevents the oxidation of the metal charged in the furnace, and also aids in forming a blanket of flame to cover the entire charging space, insuring, with the aid of the burner, the uniform distribution of the flame and heat.

Liquid fuel is especially valuable in the equipment of air furnaces, for the reason that it makes a superior grade of metal and insures its uniformity from day to day. Furthermore, the various alloys are thoroughly mixed and though, in some cases, the fuel costs more than in ordinary practice, the better quality of metal offsets any difference in cost. This style of furnace can also be used to a very good advantage in making semi-steel.

In brass melting furnaces in brass foundries, oil if properly installed, is an excellent fuel. An air furnace is used to reduce scrap brass so that it can be run into ingots for remelting. In mould drying, core drying or japanning ovens, liquid fuel can be used to advantage because a uniform distribution of heat throughout the entire length and width of the ovens can be obtained. It is important to avoid the use of stacks on such equipment, but the moisture should be permitted to pass out of the top of the oven. By this method a great saving is effected in the construction of the oven. Where small ovens are used for core drying, etc., one burner to five or six ovens renders better service than a single burner to an oven.

* Abstract of Paper presented before the Philadelphia Foundrymen's Association.

The Influence of Oxygen on the Properties of Metals and Alloys.

Discussing this subject recently before the Institute of Metals, Mr. E. F. Law, Assoc.R.S.M., pointed out that the existence of oxides in metals and alloys is usually ignored, inasmuch as they are not determined in the ordinary course of chemical analysis, and they frequently escape detection by mechanical tests. Nevertheless, they play an important part in the behaviour of the metals when in service, and the author contends that they are all the more dangerous on account of the ease with which they may escape detection by the ordinary methods of testing. Attention is particularly directed to the influence of oxides on the corrosion of metals, and the author states it as his opinion that experimental work on corrosion which does not take into account the presence of oxides in the metals experimented upon is of little value.

The Production of Small Castings.

By W. H. Hatfield, M.Met.

There was a large attendance of members of the Sheffield Branch of the British Foundrymen's Association on November 26, when Mr. W. H. Hatfield, M.Met. (a director of J. Crowley & Company, Limited), gave a lecture, illustrated by lantern slides, on "Metallurgical Considerations in the production of Small Castings." In the absence of the President of the Branch (Mr. Percy Longmuir, M.Met.), the chair was occupied by Mr. H. Pilkington.

The lecture was largely illustrated with micrographs, etc., and a detailed account therefore is somewhat difficult without a number of plates. The lecturer opened with a detailed account of the equilibrium diagram of the iron-carbon system, and by its aid discussed the general properties and condition of casting of the commercial alloys of steel and iron. He pointed out that the equilibrium diagram refers only to pure iron-carbon alloys, and that wherever other elements are introduced, as is invariably the case, the theoretical data obtainable from the basic diagram do not directly apply. It was demonstrated how silicon modified the melting point and subsequent properties of the eutectic alloy, the eutectic alloy being the most fusible of the iron-carbon alloys. It was further shown how manganese, nickel, chromium, etc., also affected the thermal phenomena, and the lecturer also emphasised the vast changes brought about by the introduction of phosphorus in iron such as those used in the iron foundry. By means of the iron-carbon diagram, the solidification points of varying carbon steels and cast iron was made obvious. The lecturer then considered the cooling phenomena of steel castings of variable compositions, and indicated that the freezing point of such alloys lay between 1,400 deg. and 1,500 deg. C. He explained that this was the reason for the necessarily high initial temperature prior to leaving the furnace. The difficulties of casting small steel castings were in this way explained, it being shown that in excess of the freezing point 200 deg. to 300 deg. of superheat were necessary to allow the metal to run the small casting. This involved special attention to the mould and also to feeding. He then went on to describe the various cast irons and malleable irons, dealing largely with the microstructure of such material. It was shown that all pig-irons practically consist of the eutectic alloy for the given composition, and by means of the iron-carbon diagram it was indicated that owing to the metal in the blast furnace being in contact with a surplus of carbon (coke), free carbon (kish) must be given off from the irons between the time of leaving the blast furnace and final solidification. The lecturer explained the formation of kish as being the result of the decomposition of the carbide (carbon of supersaturation, *i.e.*, that over and above the quantity necessary to produce the eutectic), during the cooling of the metal down to the freezing point. This view of the subject became apparent with the assistance of the diagram. The lecturer then went on to show by means of micrographs that the graphitic plates found in cast iron formed immediately upon solidification and were due to the presence of silicon rendering the carbide unstable, the result being that when the carbide separates from the eutectic during freezing, it immediately breaks up into free carbon (graphite) and the pure iron liberated immediately passes into the solid solution. The lecturer showed the microstructures of various irons upon the market, including hematite and phosphoric cast irons, and also white irons used in the production of malleable cast iron. One interesting slide consisted of a micrograph of a Derbyshire pig which broke in two on merely being dropped on the floor. It was seen that the graphite and phosphide were present in a most dangerous form. The next slide was of similar material after it had been melted and cast, and thereby comparison of the structures obtained from the casting and from the pig was made possible. The lecturer here pointed out that the presence of phosphorus in these irons resulted in the formation of a ternary eutectic of iron, carbon and phosphorus, which has a melting point very considerably below that of the iron carbide eutectic, and he further pointed out that the presence of this eutectic also resulted in the lowering of the freezing point of the primary eutectic. In other words, this was the reason why phosphorus rendered pig-iron more fusible.

Having dealt with cast irons, the lecturer then went on to malleable cast irons, and having pointed out the ease with which such material could be made into small castings, demonstrated by means of the lantern the microstructures of such castings, both as cast and heat-treated. One section, which was of the American or black-heart malleable cast iron, it was pointed out, possessed a purely ferritic structure analagous to that obtained from a piece of wrought iron; but whereas in wrought iron there was a lot of slag present, in such a casting this was merely replaced by free carbon. The difference in composition and treatment incidental to the two distinct malleableising processes, *i.e.*, American or black-heart and European or Reaumur, were gone into, and the lecturer then proceeded by micrographs to illustrate the effect of varying composition of the irons upon the various constituents present in the casting. He gave particular attention to the modification of the properties of the cementite carbide, and this, he explained, was a very important aspect of the heat-treatment of such small castings. The last slide consisted of a number of tests obtained from heat-treated castings, the tests obtained from them being all comparable, whilst the analyses differed most widely, the silicons varying from 0.45 per cent. to 1.8 per cent. He explained that providing the correct condition of the carbon in the final casting was attained, the variation in composition was secondary.

Discussion.

Mr. H. Brearley said they all knew the difficulties of producing small steel castings. He then referred to Mr. Hatfield's remark that in the final stages of the production of the black-heart malleable castings the silicon decomposed the pearlite that was formed soon after the change point. If that took place in that particular manner in a black-heart casting, could Mr. Hatfield explain how it came about that a steel casting containing, say, 0.3 or 0.4 per cent. of silicon did not also form the small graphite particles? Mr. Hatfield also told them that the sulphur prevented the graphite which separated from balling up and decomposing. One of the bones of contention in relation to the metallurgy of iron and steel was the particular range

of temperature at which the balling up of the pearlite took place, and he should like to put it to Mr. Hatfield whether it was not possible or feasible, in the treatment of malleable castings that the formation of the graphite, and the absence of either free pearlite or free cementite, were due to that kind of phenomena which the Germans called "Impfen," or, literally, vaccination. What he meant was that when there was existing in a metal a substance like graphite, the very presence of that graphite had a very strong tendency to transform all other forms of carbon into its own particular state. Mr. Brearley also asked whether the graphite which formed in black-heart castings was deposited on heating up or on cooling down.

Mr. T. Swinden said, with regard to the content of silicon in the carbide, it must have been a very difficult thing to prove absolutely that silicon was combined in the carbide, and not present free, as silica in the carbide residue.

Mr. Dickinson referred to Mr. Hatfield's remarks about the existence of pearlite in the Reaumur castings. Mr. Hatfield had stated that in the blackheart castings all the temper carbon was produced by the annealing process, but that in the oxidised casting—the one that had been annealed in ore—the metal showed pearlite, with, of course, temper carbon, and that this was due to the sulphur present. He thought that point ought to have been dwelt on rather. In one case they had pearlite showing, and in the other temper carbon and free iron, and Mr. Hatfield said that the pearlite was there by reason of the sulphur contained. He thought it would have been better, in a case like that, if he had said that the structure would have been the same if they had given the same treatment apart from the ore, because as he understood it the object of using ore in the process was to remove the carbon, and they ought to get complete precipitation of the carbon—there ought not to be pearlite there any more than in the other.

Mr. Hyde did not think Mr. Hatfield meant to convey the idea that the annealing in the ore process was the same in effect as in the blackheart process. He always thought that malleablising in the ore process was due to the chemical action in which carbon was taken out of the casting by the oxygen of the ore, whereas in the blackheart process he understood that the alteration in the carbon content was only just on the skin, and did not penetrate to any depth whatever.

Mr. Paton referred to the influence of the electric furnace on the magnetic properties of iron. He said the actual structure of a final iron was greatly determined by the passage of the current in the furnace. If they took an ordinary Lavalle furnace, the actual passage of the current through a stream of molten metal had a tendency to arrange the molecules of the iron, and, finally, when the steel was investigated, it had an ideal structure for magnetic properties. By arranging the molecules in a continuous formation, the furnace also had a tendency to increase the tensile property. In molten metal too, there were various constituents—silicon, iron and carbon—which had a certain electro relationship, positive and negative, and might constitute innumerable thermo-couples in the actual material. If they heated the units which constituted a thermo-couple, they had a small current of electricity which might, in the actual mass of metal, be a local circuit. He asked whether any investigation in this matter had ever been carried out.

The Chairman said he wished someone would state the exact time at which kish sweated out of pig-iron. The question of fluidity in pig-iron had been mentioned. Of course, there were other questions involved in it, but he had always had an idea that phosphorus and fluidity were synonymous expressions. He should also like to put a question to Mr. Hatfield with regard to segregation in cast iron. If they started with the purest pig-iron possible, he presumed that in a large mass there would be some segregation; and if they started with the dirtiest pig-iron possible he presumed there would also be some segregation. Could they avoid segregation by the purest material that they could possibly buy? As a practical man, he was extremely sorry to hear that the lecturer was rather down on tensile tests, which he believed were the only safe tests on cast iron. He should like to know upon what was based the tradition of the defects caused by sulphur in the final malleable casting.

Mr. Hatfield, in reply, referring to a remark by the chairman, said that a malleable casting, properly made, was very similar to wrought iron. He had shown that in those castings they could obtain from 23 to 24 tons tensile, with 19 per cent. elongation. Was that much inferior to wrought iron? Strictly, it was not wrought iron, because it was cast, but in spite of the difference in process he ventured to say that the similarity of result was somewhat obvious. With regard to the separation of kish from pig-iron, he thought they now practically understood the temperatures at which it separated. He thought he had shown, by means of the equilibrium diagram, that the molten iron accumulating at the bottom of the blast furnace was at a much higher temperature than at the time it solidified, and therefore, owing to the surplus of carbon present, it contained in solution more carbon than was necessary to form the eutectic alloy. The surplus carbon, during the cooling down to the freezing point, was given off. It was in solution in the molten iron as carbide, but the carbide was thrown out of solution and decomposed, and therefore he contended that the kish was produced all the way down to the freezing point. The molten iron, in the presence of an excess of carbon, must combine, according to the phase rule and the equilibrium diagram, and must contain a surplus of carbon, which must be given off prior to freezing. That was his theoretical explanation of the separation of kish. He quite agreed with Mr. Pilkington that the presence of phosphorus and fluidity were synonymous expressions. He did not think he had given Mr. Pilkington cause for his remarks upon cast-iron test bars. Figures were given up to 22.8 tons, but cast iron nevertheless was relatively unsatisfactory from this standpoint.

With regard to segregation, if an alloy was composed of several constituents, or, to speak more correctly, several phases, it followed that during the slow cooling of a large mass these different phases would segregate, and it seemed to him that whether the pig-iron were pure or impure, considerable segregation would occur if the iron were cooled slowly. Fortunately, the cooling of a casting was relatively rapid, and therefore he thought that whether a casting was pure or impure, in a casting there was relatively little segregation. That was his experience, founded upon analyses of large castings in different parts of the same casting. With regard to the influence of sulphur in the final malleable casting, he had no doubt that they might show him a key bent absolutely double, or a large casting which was very considerably distorted, with a content of 0.5 per cent. of sulphur. Sulphur seemed to have very little influence with regard to malleability, provided the correct condition of the carbon was arrived at.

He entirely agreed with Mr. Brearley's remark as to the influence of pre-existing free carbon upon the dissociation of the remaining carbide. Mr. Brearley asked, as his preliminary question, why, in silicon

steel, the pearlite graphite did not break down. He put it to Mr. Brearley that he answered that question by his later statement as to the presence of already existing free carbon, which had been produced at a higher temperature, being responsible for the encouragement of the precipitation. In the malleable casting there was free carbon produced at high temperatures, and as the casting cooled down the recalescence point was arrived at with free carbon already present. When the solid solution broke up, that free carbon assisted in the precipitation of the carbon in the malleable casting. His explanation was that in steel they had no free carbon, that at the recalescence point they had the precipitation of free carbide, and owing to the absence of free carbon the carbide was able to persist. It was purely theoretical, but he believed that that was the explanation of the difference which Mr. Brearley indicated. Mr. Brearley asked: "Is graphite decomposed going up or coming down?" Well, he thought his slides would indicate that carbide of iron exposed to high temperatures decomposed, and he believed that the mass of the precipitation took place at high temperatures. The latter stages of the going up would result in precipitation, and also the maintenance at high temperatures, but the bulk could only be decomposed during the descent, because previously a lot of the carbide was in solution at high temperatures, and it was only when it could come out of solution that dissociation could take place. Mr. Swinden had asked whether he was really certain that the silicon indicated as being in the carbide was in the carbide. Well, Mr. Swinden had done a lot of research on the same lines with regard to other alloys, and he (Mr. Hatfield) thought they were both agreed that the methods which they used were at the best only approximate. They were rough, but they were the best available, and as the result of his experiments he felt convinced that the silicon was in solution in the carbide as silicide of iron. It was obviously not present as silica, because if the carbide were washed with sodium hydrate, hard silicon would be got away. It was a purely chemical explanation, but he thought he had grounds for his statement that the silicon was in the carbide. Perhaps he ought to explain that there were solid solutions as well as liquid solutions. One solid could dissolve and did dissolve another. In the cementation process solid iron absorbed solid carbon. In just the same way the silicide of iron was probably in solution in the carbide of iron.

Probably he might have been a little clearer on the point mentioned by Mr. Dickinson, but that gentleman could take it from him that if he took two alloys, one containing sulphur and one not containing sulphur, and heat-treated them side by side—leaving out of consideration the packing—he could obtain a complete precipitation in the one iron, but in the other he would invariably have a pearlite matrix. There was something inherent in the sulphurous alloy which did distinctly prevent the separation of the final free carbon. He would refer Mr. Hyde to his Paper, given in 1909 before the Iron and Steel Institute, in which he very thoroughly thrashed out the theory underlying the decarburisation process, and he had reason to believe that the theory he there laid down had the support of most metallurgists at the present time. It amounted to this, that a decarburisation took place, and the carbon content was gradually lowered, owing to the exposure of the iron to the oxide of iron. But decarburisation alone would not produce a malleable casting. There must be a breaking down of the carbide, and therefore the process was twofold—decarburisation and decomposition of carbide. The first stage was the decarburisation at lower temperatures, and then, when the iron got to a suitable temperature, the remaining carbide broke down, giving a malleable casting. With regard to the time and temperature of the heats, he gave these micrographs in a comparatively recent Paper, in which Mr. Hyde would find all the particulars he asked for. In making the remark about a heavy and apparently strong piece of pig-iron which broke with a clean fracture on being thrown down, he did not intend any general condemnation of Lincolnshire or Derbyshire irons, for, of course, these were the basis on which many of them worked in producing some classes of castings. It was essential to vary the quantity of silicon according to the size of the casting. A large casting, with, say, 0.7 per cent. of silicon, might be grey, whereas a little casting from the same material would be white, so that it was very necessary to modify their analyses. He was very much interested in Mr. Paton's remarks, because they dealt with the production of steel in the electrical furnace. But, although he had no conclusive evidence on which to base the statement, he ventured to say that the electrical melting did not materially alter the properties of the subsequent steel. Steel with 0.5 per cent. carbon and 1 per cent. manganese, produced in an electrical furnace, would have the same magnetic properties as an identical steel produced by the open-hearth or Bessemer process. The process was of very little importance, providing the same product was obtained, and he thought that the differences which were often ascribed to process were generally the result of the fact that the products were not the same. They might appear the same from the evidence which one could procure, but it was quite possible that certain evidence might be lacking.

Blast Furnace Working in China.

This subject is discussed in a recent issue of "Stahl und Eisen" by Mr. F. Lux, of Herne, who was engaged for many years in connection with the Pinghsiang coal mines and ironworks, where alone in China coke is made on European lines on a large scale for the adjoining ironworks. The author also had the opportunity of becoming acquainted in the provinces of Kiangsi and Hunan with the most primitive methods of coke manufacture as practised by the Chinese, and also with some blast furnaces whose type of construction likewise dates back a very long period. The construction of the coke ovens used is simple and cheap, and the labour is cheap, but the losses of fuel are considerable. The coke is used by the Chinese themselves partly for the smelting of iron ore, which comprises limonite, blackband, and occasionally red iron ore. The blast furnace consists of a conical vessel, 6 ft. 6 in. high, formed in two halves, and strengthened by iron bands. Two openings are provided in the bottom, one being for the admission of compressed air and the other for tapping the molten iron. A hollowed-out tree trunk, fitted with flap valves, is used to produce the blast by means of a leather-packed wooden piston, which is moved to and fro by hand, and the blast is conveyed to the furnace by a tube. The furnace itself is suspended above the ground, and is capable of being tilted by about 30 degrees for tapping purposes, whilst the charging is effected from a ladder, the charge being mostly brown iron ore and blackband with coke produced in the vicinity. The furnace is tapped once an hour, and the daily output ranges from 9 cwts. to 13 cwts. of iron, according to the quality of the ore, 1 cwt. of coke being needed for each 1 cwt. of iron. The cost of 1 cwt. of coke amounts to 1½d. and that of iron ore 1½d. per cwt., whilst 1 cwt. of iron was sold at the works for 2s. 1d. The iron, which is cast in small bars and plates, yielded on analysis, a high content of sulphur and silicon. It is not very hard, and is used for the production of utensils for domestic and agricultural purposes.

Semi-Steel in the Iron Foundry.

Some interesting notes on the use of semi-steel are contained in a pamphlet issued by David McLain, of Milwaukee, Wis., U.S.A., from which we take the following :—

Many open-hearth steel plants to-day, having their own iron foundries, buy rolls and other special castings from firms who make a speciality of rolls, etc., but the writer has made high-grade semi-steel rolls; melting the metal in the regular open-hearth furnace, which is really the ideal furnace for making semi-steel for large castings. Semi-steel is the "connecting link" between iron and steel, combining the fine wearing qualities of iron with high strength and many of the best characteristics of steel, without any of the serious defects found in the manufacture of steel castings, such as cracking, blow holes, hard spots, etc.

The Company of which the writer was foundry superintendent had just built a foundry to make iron, steel and brass castings, having previously purchased all castings from jobbing shops, which practice proved very unsatisfactory, as the castings consisted of parts for air-brake equipment used on street cars. The records of the machine shop proved that the loss on small cylinder-head castings ran as high as 60 per cent., which loss was not discovered, unfortunately, until castings were machined and put to the test, which was 200 lbs. air pressure. Investigation proved there were also large losses on this particular cylinder-head pattern in every foundry in which it was placed. At the time referred to, the pattern was in a foundry having a good reputation for this class of work, and as their losses were only about 50 per cent., the machine-shop superintendent advised that the pattern be allowed to remain there. Eventually, however, the pattern was called in, and in a short time the loss was reduced to 35 per cent., and as a plan had been devised to test castings before machining (not a final test) the company was immensely pleased with the showing.

But a loss of 35 per cent. on iron castings, when the writer had been able to make steel castings with a loss of 2 per cent. and under, was very discouraging. Experts were called in, chemists had their say, but without bettering the product. Foundry friends all advised that the pattern be changed, but the manager would not listen to it, as he claimed when the metal was right, castings were right, and later developments proved that he was correct.

The writer gave much study to the use of steel, also to the thought that manganese must be used, but on referring to text-books, found the following information :—

"Manganese increases the saturation point of iron for carbon."

"Manganese will remove sulphur if used in the ladle."

"Manganese is a hardening element above 0.85."

"Manganese is no good when used in cupola, because the temperature is not high enough to melt it."

"Manganese converts graphitic carbon to combined carbon."

"Would steel increase the temperature of the metal? No."

In the face of all this expert opinion it appeared better to leave steel alone, but several incongruities in the above statements left a loophole to work on. The statement that manganese converts graphitic carbon to combined carbon appeared all right, if there was no silicon in the mixture, but as silicon converts combined carbon to graphitic carbon, what would happen if both manganese and silicon were fairly high? All text-books state that steel is used to reduce carbon, but how is one to make soft castings of light section if the total carbon is low? It was apparent that if manganese increased the "saturation point of iron for carbon," it was necessary to use it, because if carbon is low, light sections will be hard, but as silicon must be low for close-grained metal, probably a low silicon, high-carbon metal would solve the problem, and it did.

When figuring the estimated analysis of the material in the charge entering the cupola, the total carbon was only 2 per cent. Now it did not matter how high the silicon was in the castings, they would be hard if the total carbon was only 2 per cent., but when the metal was poured and analysed it was found that the carbon had increased to 3.58 per cent. and these light castings were soft although the silicon was low. The steel and manganese did exactly what they were calculated to do, namely, increased the total carbon, reducing the sulphur and allowing the lower silicon mixture to be used, thereby giving a very close-grained metal, free from segregation and blow-holes.

When it is stated that the pattern sections were as light as 5-16 in. to 3-8 in. and using 30 to 40 per cent. steel, the castings were run through milling machines to the tests with a loss of 2 to 3 per cent., it will be agreed the results were remarkable. The transverse test results increased from 2,200—2,400 lbs. up to as high as 4,400 lbs.

Some foundrymen who are unable to make a close-grained metal requiring high strength, or which must stand hydraulic or other tests, use expensive alloys, but when it is known that cheap steel scrap used in cupola mixtures will make light castings with a transverse strength of 2,600 lbs. to 3,200 lbs. and from 3,200 lbs. to 4,500 lbs. for medium and heavy castings, it will be agreed that steel scrap solves the problem. Good melting is a great essential, however, in using semi-steel.

Semi-steel is far superior to the ordinary metal made from grey iron in either cupola or air furnace, and for strength, homogeneity, durability and fine wearing qualities it has no superior. It is made in the same cupola as regular mixtures. Were it necessary to install or use a separate cupola it would be worthless commercially. In making metal for high-grade castings, steel and other scrap with pig is placed on the bed, making as many charges of semi-steel as desired, following with usual mixtures.

If metal for dies, anvil blocks or castings of like character is desired, semi-steel may be made on the latter part of heat. If proper precautions are taken there will be no "bunging" up of the cupola—no harmful effects to later charges of regular mixtures.

No more coke is necessary to melt steel mixtures than for grey iron, but it is best to use a heavier split of coke between the last charge of semi-steel and following charge to prevent the latter from melting through. Contrary to all previous advice offered by "experts," the steel melts quicker than the pig-iron.

The best evidence that steel will mix with iron is proven by the fact that light cylinder-head castings containing 30 per cent. steel are being run through milling machines in thousand lots with less than 2 per cent. loss—the machine operators not being aware that the metal is semi-steel.

Steel scrap should never be used in the ladle, but charged in the cupola, as a high temperature is necessary to melt steel properly, in order to liberate all gases. Steel borings and turnings may be used to advantage, charged in the same manner as for grey iron, no boxes or cans being necessary; all kinds of steel scrap, such as steel foundry scrap, gates, risers, boiler clippings, punchings, shearings, struc-

tural materials, rails, rail-road scrap, etc., may be used, while a percentage of wrought iron may also be used.

As regards the percentage of steel scrap to use in different classes of castings, steel clippings may be used in stove plate mixtures; 10 per cent. to 20 per cent. steel scrap in agricultural, automobile cylinders, plough points and other light castings; 20 per cent. to 30 per cent. steel scrap in air, steam, ammonia and gas-engine cylinders of light section, pistons, piston rings, valves, etc.; 25 per cent. to 40 per cent. steel scrap in cylinders of heavy section, automobile flywheels, acid pans, engine bed and boiler castings, brake shoes, medium gears, machinery castings, pillow blocks, permanent moulds, hydraulic and locomotive cylinders, car wheels and chilled castings, etc.; 40 per cent. to 50 per cent. steel scrap in large chilled castings, crusher jaws, concaves, cones, anvil blocks, medium and heavy gears, heavy cylinders, rolling-mill castings, large permanent moulds, etc.

Electric Heating and the Removal of Phosphorus from Iron.*

By Albert E. Greene.

In this Paper the author suggests new possibilities in removing phosphorus from iron, and thereby making available for use the high-phosphorus iron ore. The various reactions of phosphorus associated with iron are summarised as follows :—

(1) At temperatures under 1,450 deg. C. phosphorus in pig-iron has greater affinity for oxygen than has the carbon in the pig-iron, but less affinity for oxygen than solid carbon in the presence of pig-iron.

(2) At temperatures above 1,450 deg. C. the affinity for oxygen of the carbon dissolved in iron becomes greater than the affinity of phosphorus in the iron, and the dissolved carbon can reduce calcium phosphate in the slag, as, of course, solid carbon can do also.

(3) In the presence of lime and iron-oxide, and in absence of silicon or solid carbon, phosphorus oxidises to calcium phosphate.

(4) Silicon reduces calcium phosphate nearly always, but there may be a range of temperature under 1,450 deg. where phosphorus oxidises to calcium phosphate more easily than silicon to calcium silicate.

(5) Solid carbon will reduce calcium phosphate contained in a slag or bath of iron, and phosphorus will go into the metal.

(6) Calcium phosphate can form without oxidation of iron in presence of carbon dissolved in pig-iron at low temperature.

(7) Calcium phosphate can form without oxidation of iron in absence of carbon and silicon at high temperatures, *i.e.*, above 1,450 deg. C.

(8) Oxide of iron can be reduced without reduction of calcium phosphate contained in some slag.

(9) Solid carbon is a stronger reducing agent than carbon dissolved in the iron, probably because of the affinity of the metal for carbon.

It is apparent that in all the present processes the complete control of at least one important factor is either lacking or has not been utilised. In the open-hearth process it is the control of the reducing conditions that is limited and likewise in the Bessemer process; but in this latter process the control is further limited by the necessity of raising the temperature by oxidation of elements in the charge itself. In the electric furnace, however, where heat can be produced independently of combustion or chemical reaction, this important factor—namely, intensity of reducing conditions—can be controlled at will and with ease. Up to the present time this fact appears not to have been appreciated by metallurgists, judging by present methods. It is in the complete control of the reducing conditions that important possibilities of electric heating lie, and as this fact becomes more generally recognised and used, it is probable that some method will be devised for measuring the intensity of reducing conditions or equilibrium conditions. Since the intensity of reducing conditions is the reverse of the intensity of the oxidising conditions, the term "oxygen pressure" may find a use as a measure of them.

Among the reactions made possible by control of the reducing conditions and temperature simultaneously, is the reduction of oxide of iron from a slag containing calcium phosphate without reduction of the phosphorus contained therein. Naturally the origin of the phosphorus-containing slag or charge is immaterial; it may be raw ore containing phosphorus, or it may be a slag in which some of the original oxide of iron served to provide the oxygen for combination with phosphorus, the oxide of phosphorus subsequently combining with lime to form phosphate. Or the reducing conditions may be so controlling as merely to prevent oxidation of iron, which, at the same time, causes phosphorus to oxidise and combine with lime.

The author states that in his experience along this line it has been found that at temperatures below about 1,400 deg. the phosphorus was easier to oxidise than carbon from pig-iron. And it was found that the phosphorus could be oxidised in the presence of lime without any resultant oxidation of iron and with practically no oxidation of carbon; that phosphorus could be oxidised in the presence of lime without oxidation of manganese, and a very interesting further observation was made, namely, that at certain temperatures between the melting point of pig-iron and about 1,350 deg. C., phosphorus oxidised in certain cases in the presence of lime without any appreciable oxidation of silicon. This would indicate a reversal of oxygen affinity of these elements—phosphorus and silicon in pig-iron in the presence of lime.

A fusible slag results from proper proportions of acid and basic radicals. It has been found that the silicon content in the slag may be as high as 30 per cent. without apparently hindering the removal of phosphorus. Phosphorus was separated in slags containing this much phosphorus, and yet practically no iron oxide was present in that slag. This points to the possibility of a low melting-point slag for holding phosphorus.

The reduction of oxide of iron from a charge of slag containing phosphorus as calcium phosphate, without reduction of the latter, requires essentially the same control of the conditions as does the selective oxidation of phosphorus in presence of lime forming calcium phosphate, without oxidation of iron. Electric heating is the only practical way of accomplishing such control.

* Abstract of Paper read before the recent International Congress of Applied Chemistry, at New York

Writing on the subject of low melting alloys, in an Austrian contemporary, Mr. E. Murmann states that by replacing the lead by thallium in low-melting alloys one obtains similar alloys. A mixture of 2.48 parts by weight of Cd. 3.57 of Sn, 4.082 of Tl and 12.51 of Bi. gives an alloy which softens at 95 deg. and melts indistinctly at 100 deg.

According to A. Portevin, who recently experimented with alloys containing up to 20 per cent. Zn, and rich in Al., if these alloys are to be used for aeroplane castings, etc., it is well not to exceed 20 per cent. Zn.

Mathematics in the Foundry.

The second meeting of the Session of the Birmingham Branch of the British Foundrymen's Association was held at the Municipal Technical School, on Saturday, November 23, Mr. H. L. Reason (President of the Branch) in the chair.

Mr. E. L. Joselin gave an address on "Foundry Calculations." Dealing first with arithmetic, he said that a great many foundrymen had not had the advantage in their early days of learning decimals sufficiently to be able to use them readily in ordinary everyday work. The result was that decimals instead of being, as they ought to be, the easiest way of making calculations, were to many of them the most difficult. Decimals were simply a way of numbering in tens. He supposed that primitive man started with tens by counting on his fingers, that being the easiest way of numbering. Having explained the theory of decimals, Mr. Joselin gave on the blackboard some examples of multiplication and division of decimals and illustrated the advantage of the use of decimal notation in arranging percentages of mixtures. Taking a supposed alloy, the constituents of which he named A, B, and C, in the proportions of A, four parts, B, seven parts, and C, one part, Mr. Joselin set these proportions out decimally as A, 33.3 per cent.; B, 58.3 per cent.; C, 8.4 per cent.; total 100. Then he showed that the relative percentages, if an alteration were required, could be varied much more easily and minutely by altering the decimals than was possible when the proportions were set out as so many parts in twelve, or by any method involving the use of vulgar fractions. Having given instances of useful decimals to remember, as representing fractions frequently occurring in practice, Mr. Joselin dealt with squaring and the square root, and showed how to extract the square root where whole numbers and also where decimals were concerned. Having shown what was meant by cubing a number, he illustrated the extracting of the cube root; but, in view of the complexity of the process, he did not recommend his hearers to waste their time upon it, unless they were miles away from their tables.

Illustrating how measurement of surface and thickness would enable one to ascertain the weight of a plate, the lecturer said that the weight of a cubic foot of cast-iron was from 455 lbs. to 480 lbs. This would make the weight of each square foot of plate for 1-in. thickness, 38 lbs. to 40 lbs.; for a ½-in. plate, 19 lbs. to 20 lbs.; for a ¼-in. plate, 9 lbs. to 10 lbs. for a ⅛-in. plate, 4.75 lbs. to 5 lbs., and so on. With these figures as a basis, they had only to get the area of their plate in square feet (with or without decimals, as the case might be), and multiply that number by the weight per square foot for that particular thickness, and so get the weight in pounds and decimals of pounds. These figures were for cast-iron. To make the result correct for wrought-iron it would be necessary to multiply the result by 1.06; in other words, wrought-iron is 6 per cent. heavier than cast iron, though the figure might vary slightly for different irons. For ordinary brass, it would be necessary to multiply the cast-iron result by about 1.14, brass being about 14 per cent. heavier. Gun-metal was slightly heavier than brass, so that for gun-metal the cast-iron figure would have to be multiplied by about 1.18; whilst for lead the multiple would be about 1.56. With a simple pattern, the weight of the casting was about sixteen times the weight of the pattern, so that for every 7 lbs. of pattern, in such a case, 1 cwt. of casting might be recorded. This rule would serve to give a quick result, but frequently reductions had to be made for prints.

Dealing next with circles, Mr. Joselin gave the formulæ for obtaining the circumference, given the radius or the diameter, and for ascertaining, from the square of either of these, the area. Having got the area and thickness of a circular plate, they could calculate its weight from the figures already given. To obtain the area of a fillet they might regard the curve of the ordinary fillet as a quarter of a circle, and the whole fillet as part of a square in which a circle was inscribed. Deducting the area of the complete circle from that of the square, and dividing the result by four, would give the area of the fillet. An example of this kind of calculation having been given in which the result came out at 0.6773 lbs., Mr. Joselin said that this showed that in nine cases out of ten, the weight of the fillet was not worth taking into account. It was only with a big casting that it need be troubled about it, but it was worth while working the thing out to convince themselves that in the case of a small casting the weight of the fillet was of little consequence.

Dealing with cylinders and pipes, Mr. Joselin showed the method of getting the weight of an ordinary straight flanged pipe. This required two operations, dealing first with the cylindrical portion, and secondly with the flanges. First, they had to ascertain the diameter of the bore of the pipe, and then the thickness. Taking a pipe of 6-in. bore and ½ in. thickness, the diameter of the outside would be 7 in., and that of the inside 6 in. By finding the areas of circles of these diameters, and deducting that of the smaller from that of the larger, the area of a section of the metal would be got. Roughly, the areas in this case would be 38 sq. in. and 28 sq. in., so that the area of the section would be about 10 sq. in. Multiplying this by the length, they would get for a 9 ft. pipe a solid content of 1,080 cubic in. Multiplying this figure by 0.263 (representing the number of lbs. of cast iron in a cubic inch) they would get the weight of the cylindrical part of the pipe. The weight of the flanges could be got by a similar process. Supposing the diameter across the flanges to be about 11 in., and the thickness of the flanges about ⅝ in., they would have to deduct the area of a 7-in. circle from that of the 11-in. circle, and so get the area of the face of each flange. Multiplying that by 2, ⅝, and 0.263 they would get the weight of the two flanges in lbs. The weight of a pair of flanges, however, differed so little from that of 1 ft. of pipe, that for ordinary purposes it was sufficient to simply add 1 ft. to the length, when calculating the weight of pipes. In socket pipes, the weight of the socket was in some cases a little less than that of two flanges, so that to include the weight of the socket they should add for large pipes about 6 in. to the length, and for small pipes about 8 in.

With regard to pipe-bends, it was impossible for him to deal with every case. Usually a pipe-bend was struck from a radius a little less than the distance from the centre of the flange. Taking a quarter of a circle of this radius, they would get the length of the pipe in the elbow. Then the distances to each end of the bend had to be added, and this would give the whole length of the piece. Taking this with the area of the section, as in the case of a straight pipe, the

weight could be ascertained by the formula already given. For a Y-piece the length was got by adding together the lengths of the centre lines of the branches.

Coming to cones and their sections, Mr. Joselin pointed out how the surface of a cone of thin metal could be ascertained by multiplying the circumference of the base by half the length of the inclined side. Multiplying this by the thickness and the weight per cubic foot or cubic inch, as the case might be, would give the weight of the metal in the hollow cone. To get the capacity of a cone, it would be necessary to take the area of the base multiplied by one-third of the vertical height. With an article such as a ladle with inclined sides, the best way to get the contents was to take the area at the level of the spout and the area of the bottom and divide by two to get the average. This multiplied by the depth would give the cubic contents. Any rake on the ladle would, as a rule, not materially affect the correctness of this result. Taking the contents in cubic feet and regarding the weight of a cubic foot of molten cast-iron as 435 lbs. to 440 lbs., the weight of metal the ladle would hold could be calculated.

Having explained the rule for obtaining the area of a triangle, the lecturer showed how the weight of a triangular rib could be ascertained by multiplication of the area by the thickness and the weight figure for a cubic foot or cubic inch of the particular metal. Taking cast-iron rings of rectangular cross-section, he explained how by taking the mean diameter and multiplying by the width and depth of the iron, and then by 0.0074 the weight in cwts. would be got. If the ring was of circular section, then instead of the width and thickness, the thickness of the section would be multiplied, not by 0.0074, but by 0.0058, to get the weight in cwts.

They frequently had to deal with a sphere or, more often, a section of a sphere. The surface of a sphere was four times the area of the circle which formed the largest section of the sphere. It was known that the surface of a hemispherical dish or ladle was twice the area of the circular top, that was supposing the centre of the sphere was level with the top. If there should be a little elongation in the shape of parallel sides, the capacity of that part could be added, working it out by the rule for a cylinder, namely, multiplying the height of the parallel part by the circumference. Having got the total surface and the thickness of the metal, the weight of the whole pot could be got at for any kind of metal as in the other cases. If the metal were fairly thick, a result so obtained would not be correct. To obtain the volume of a sphere, one must multiply the cube of the diameter by 0.5236. This result, of course, would be halved for a hemisphere. In getting the weight of a thick hemispherical pot, they would have to get the cubical contents of two spheres, one calculated for the outside diameter and the other from the inner, and subtract the latter from the former. This would give the actual quantity of metal in cubic feet or cubic inches, and its weight could be ascertained by means of the formula for the particular metal. In the case of a hollow dished plate, the section of which was not a hemisphere, but some other arc of a circle, it would be necessary to find what would be the size of the complete sphere, and imagine a cylinder round that sphere. The area of the part to be measured would be the area of a corresponding height of that cylinder. To obtain the contents of the top (or bottom) of a sphere, for instance, of a dished plate, they could take the square of the height, add three times the square of the radius, and multiply the total by the height and by 0.5236. He had used that rule hundreds of times in working out the weight of a dished plate.

Discussion.

The PRESIDENT said that the part of Mr. Joselin's lecture that struck him most was that relating to decimals. In an iron-foundry, when altering their mixtures, it was seldom necessary to work closer than 28 lbs., but in a brass-foundry they were dealing with more expensive metals, and it was found that mixtures could be made and altered with a great deal more certainty when working to the decimal system than by parts or lbs. Arithmetic was generally regarded as a dry subject, but the majority of them would feel that they were none the worse for a little rubbing up in that direction.

MR J. MATTHEWS, in seconding the proposition, said that he felt that Mr. Joselin, when he commenced his lecture, had a somewhat difficult task before him. But it had, however, been dealt with in a clear and straightforward way. He thought the lecturer might, with advantage, have said something about logarithms. They were simple to use. He always carried a table in his pocket.

The PRESIDENT said that it was the desire of the Committee that Mr. Joselin should make his Paper as elementary as possible. It was better to err in the direction of simplicity than in the other direction.

MR. JOSELIN, replying to the vote of thanks, said that so far as he had been able to deal with the matter that evening, it had been a pleasure to him. He was sorry that now he had got to know the members of the Branch, his approaching removal to London would preclude his taking any further part in their proceedings.

Modern Steel Foundry Practice.

In the course of a Paper read before a recent meeting of the American Foundrymen's Association, Mr. S. R. Robinson said that in acid practice the general construction has changed but little from the furnace of ten years ago. In building the usual 25-ton furnace it is now customary to put three rows of brick on the bottom plates and 18 in. of brick over the chill plates. The corners are not left square, but are "filleted," *i.e.*, they are filled up with brick to prevent a breakout at this point. The chequers are independent of the furnace; that is, they do not support the weight of the furnace. All furnaces are built entirely above ground with the top of the flues on a level with the ground. The use of 50 per cent. ferro-silicon in place of the 11 per cent. alloy is general now; preferably in the furnace, but quite often in the ladle. Steam as an atomising agent for oil fuel, which is extensively employed, is very seldom used, as it is now generally acknowledged a mistake to think that there is a gain in heat through its dissociation. Small open-hearth furnaces are coming into more general use; that is from 5 to 10 tons capacity. Heats of 12,000 lbs. are now being made in this type of furnace, making 140 openings of the stopper and requiring one hour to pour. The life of such a furnace should be 500 heats without repairs. The latest development in small open-hearth furnaces is the Carr furnace, of about two tons capacity, with the entirely new principle of pouring directly from the furnace into the moulds. On account of the high temperature obtained this furnace allows of the manufacture of castings of thin section and intricate design. The metal is very pure, as there is no contamination except from the flame, which is usually natural gas, although, of course, producer gas or oil can be used.

THE INDIANA STEEL COMPANY, Gary (U.S.A.), has been experimenting with the use of tar as a fuel for its open-hearth furnaces in place of producer gas. The result of these operations has been successful, and at the present time two furnaces in open-hearth unit No. 1 are being operated exclusively with tar. The tar is used in its liquid state as it comes from the by-product coke oven plant, and is handled very much like fuel oil. The burners are similar to those used for oil, and the tar is atomised with steam.

A Loam Moulding Job.

By Chas. A. Otto.

The casting here illustrated, a suction chamber, differs from general loam work in so far as it is necessary to build up a temporary seat or core box to assist in forming and drying the main core, and also in the method employed for supporting and setting the core by means of a core ring. This casting also serves to show how irregular partings can be made at any desired point in a mould.

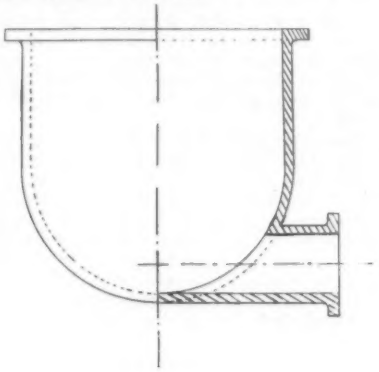


FIG. 1.

In preparing for a job of this kind the pattern-maker is required to draw a full-sized half radial section of the piece to be moulded, then to make the necessary sweeping boards and part patterns, together with the core box for the latter. It may be also necessary to make sweeping boards or segmental patterns to be used for making open-sand plates for lifting plates, cope rings, etc.

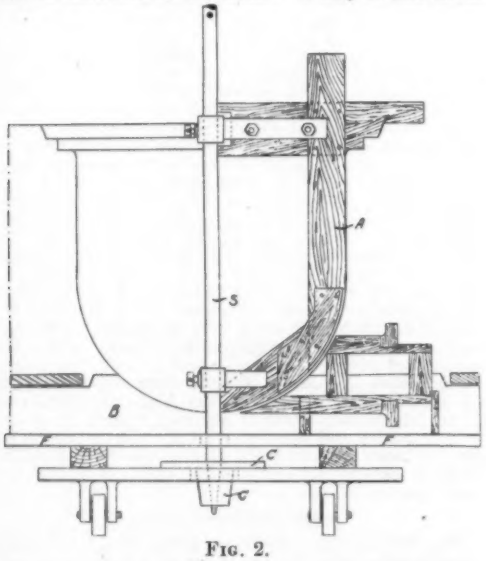


FIG. 2.

In the mould under discussion, shown in cross section in Fig. 8, it is necessary to provide some support for the cope; for this purpose the plate shown in Fig. 3 must be obtained.

In carrying out the work it is first necessary to get out a foundation plate (F, Fig. 2), a centre plate C, and spindle S; these being set on a bogie as shown, to facilitate the moving in and out of a drying stove. The sweep A is then secured to the spindle, and the lower half of the branch pattern held in position by suitable supports, as shown. The branch pattern should be made in such a way as to be clear of the sweeping board A, when set at the correct distance from the centre of the spindle. The lower part of the branch pattern should be secured in position by a weight, while the bottom portion of the mould is being built. This part of the mould (B, in Fig. 2), is built up of brick-work covered with loam and swept off with sweeping board A. When the brick-work with its loam facing is complete to the joint, an off-set parting or guide is formed, as shown in Fig. 2; this should be allowed to stiffen before commencing to build the cope.

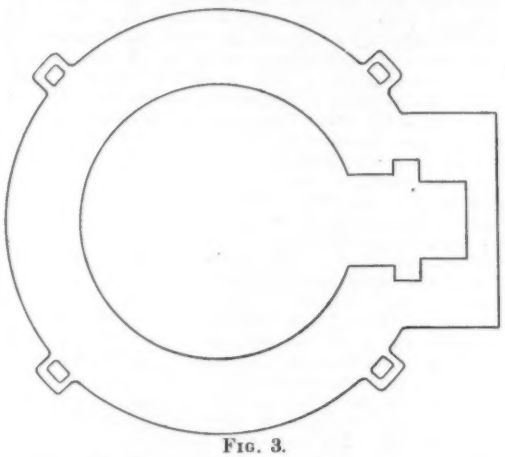


FIG. 3.

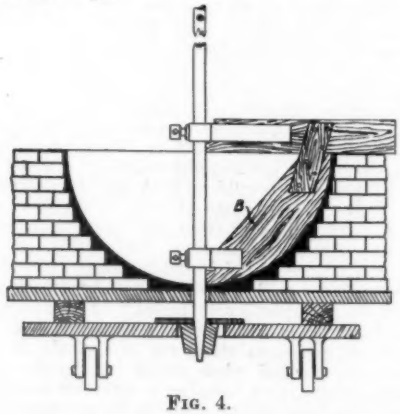


FIG. 4.

The cast-iron plate, shown in Fig. 3, is then placed upon the parting, having a thin coating of loam between, and the plate having been previously clay washed, the top half of the branch is set into its correct place. The building of the brick-work and sweeping of the loam facing with the board A is then continued, until the top of the mould is finished, having made the proper form of the flange and also a seating or guide for the covering plate. The spindle and

sweeping board can now be taken out, and the remainder allowed to stiffen or placed in a stove. The main core can then be commenced.

If this were a small casting it would be possible to sweep up the core in a reverse position and then turn it over; but in the case under consideration, the casting is too large for the method, hence the necessity to sweep out a temporary seat or part core box in which the lower part of the core can be built.

To do this a plate is levelled up and a spindle set perpendicularly; secured to this by means of tail-pieces is the sweeping board B (shown on Fig. 4). Brick

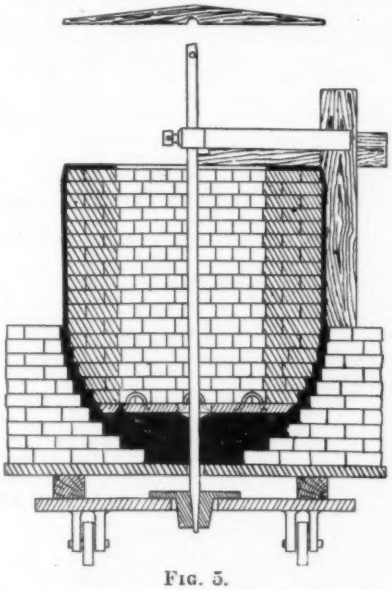


Fig. 5.

work is built up and loam applied so as to form the required core box. Care must be taken to see that the shape thus formed conforms exactly with the desired interior of the casting. The temporary cradle is then slightly dried, after which the core is built up in the manner shown in Fig. 5. First an amount of loam is placed in the bottom and into this is embedded a core or lifting plate having a number of prongs cast on it and a number of irons cast in it which can be bent to the desired shape; the whole having been well coated with clay wash, then brick work is built upon the plate, a loam facing being

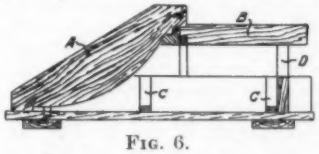


Fig. 6.

placed next to the seat until the top edge is reached. The upper or parallel portion of the core is then built up and swept off with a sweeping board, in the same way as any ordinary cylindrical piece. The sweeping board and spindle are removed, and the remainder put into a drying stove.

It is next necessary to make a core for the branch. A skeleton box, such as is shown in Fig. 6, would be found suitable. A bearance being made by using C. C. as grounds for a strickle, sweeping out a semi-circular opening equal to half the core, this can be filled in with loam, having a suitable grid bedded in and vent made, and then strickled off the top with strickle B resting on grounds D D, and the curve to fit the main core swept by means of strickle A, revolving on a centre pin. The loam work ought to be fairly stiff before any woodwork is removed.

The top part of the mould is now necessary, *i.e.*, a covering plate, which serves both to cover the mould and to locate the core centrally. The method for constructing this is shown in Fig. 7. The plate is first levelled up and loam applied over the prongs, which ought to be coated with clay wash, and swept off with a suitable sweeping board. This plate is provided with holes through which bolts can be passed and secured to the lifting lugs in the core plate. The

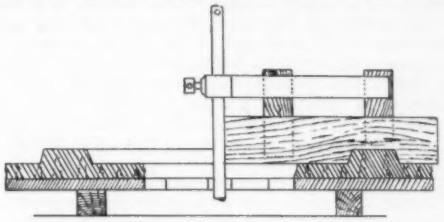


Fig. 7.

cope can now be taken out of the stove, the top portion removed, and the branch pattern taken out. The hole through which the spindle passed can be filled up and any patching done; the whole is then coated with blacking, the top cope replaced and restored. As soon as the core and covering plate are dry they can be secured to each other, and the whole lifted to be cleaned and coated with blacking, afterwards returned to the seating and stoved. The branch core is treated in a like manner. When these are thoroughly dried the closing of the mould can be commenced. First the upper portion of the cope is lifted and the branch core set in position and supported by chaplets; the cope is then lowered in position, a chaplet being placed between it and the branch

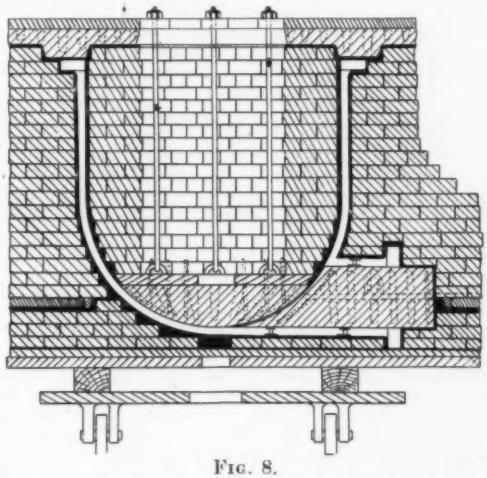


Fig. 8.

core. Next the cast-iron ring or cover plate, together with the core, are lifted from the temporary seat and lowered into position. At first they are lowered carefully, while strips of clay are interposed at various points to test the metal thickness. The parts are then separated and if the thickness indicated by the pieces of clay is as required for the metal, the parts are again assembled and bolted together ready for casting; the cover plate is bolted down to the foundation plate, weights being placed over the top clear of the runners, these also being secured to the foundation plate. The gating of the mould will vary according to the individual experience of the moulder in charge of the work.

Open-Hearth Furnace for Malleable Cast Iron.*

By G. A. Blume Stockholm).

Cupolas and even crucibles for malleable work are still more common in Europe than air furnaces. The author tried to run a malleable-iron foundry in Europe with American methods, but it was very soon apparent that great modifications were required to accommodate these methods. Among others, the question of melting-furnaces soon became a problem not easily solved. The one at first built was of the air-furnace type, with a comparatively straight top, a narrow opening into the stack and blast both below the grate and through four nozz'es over the bridge; the melting capacity was about eight tons per heat. The town authorities, however, viewed with awe the flame which issued from the top of the short smoke-stack, and furthermore, good coal was hard to obtain and very expensive, as also were good men, capable and willing to handle the coal shovel and to rabble the iron bath. The loss of heat from the stack also could not be long endured.

Experiments were then made with a new air furnace using pre-heated blast, which was forced through flues running under the neck of the furnace; but the scheme was soon abandoned. A suggestion to make the air furnace recuperative by means of heating chambers underneath the floor level and below the furnace proper was discounted on account of the cost. Finally attention was turned to the open-hearth furnace. The use of open-hearth furnaces in the malleable cast iron industry is not a novelty, and its application for this work has been to some extent successful.

Experiments with Open-Hearth Furnace.

The author made arrangements to conduct a series of trial meltings in an acid open-hearth furnace at one of the best known larger steel works in Scandinavia. These experiments proved very satisfactorily the value of the open-hearth furnace. In December, 1910, the first application of the open-hearth according to the author's suggestions was made and a second furnace was built in 1911 and started in the beginning of 1912. As natural gas is unknown in Scandinavia and oil is only to be had through import from Russia or America, it was necessary to use producer gas as fuel. The result generally to be expected of substituting gas firing for coal fires, in not only the melting furnace but also in the annealing and core ovens, is saving in fuel, no waste heat, saving in labour through the concentration of the heat generation, and the possibility of more minute control of the manufacturing processes, etc. In the second plant installed the system has resulted in a complete centralisation of the heat generation to one gas-producing plant, from which the gas is conducted to the open-hearth furnace as well as to the annealing furnaces and core ovens. The furnace equipment of the plant, which is situated in Finland, consists of one acid open-hearth furnace of a normal melting capacity of two and a half to three tons per heat, two annealing furnaces and one drying oven, as well as a cupola and two brass-melting furnaces. The gas plant consists of two cylindrical gas producers with inside diameter of about five feet. Only one is used at a time, the other being kept in reserve. The gas from one producer is sufficient for the whole furnace equipment (cupola and brass furnaces excepted), even if all are running at the same time, although as a rule the annealing furnaces are run alternately.

When constructing the open-hearth furnaces in question, several modifications were embodied, with a view of making them more suitable for the melting of pig-iron and white scrap; but the main principles of the steel-making acid furnaces were followed. The principal points kept in mind have been the size of the regenerator chambers for air and gas, the method of building the checker work in these, the sizes and direction of the air and gas flues, as well as the manner and place in the melting chamber where gas and air mix and the combustion takes place. The furnace is built so low that the tapping spout is not more than three feet above the foundry floor, and the charging platform only about two feet. Tapping can thus be done in exactly the same manner as with the common air furnace, *i.e.*, in small hand ladles, while on the other hand nothing prevents placing under the spout a large crane ladle, sunk into the floor pit if desired. The annexed view shows the platform of the open-hearth furnace, illustrating the door-hoisting arrangement.

The regenerator chambers are placed altogether underground and directly under the furnace proper. This necessitated building a 12 ft. deep concrete pit with intermediate layers of asphalt to keep out the water from the surrounding water-soaked ground, and placing the whole furnace system in that pit; but this, in the author's opinion, was better than placing the regenerator chambers higher up and at the side, for the more the chambers are built to take the form of a chimney, *i.e.*, the higher they are compared to the area, the better are the results, and the more heat they will absorb and return.

Results of Experimental Plant.

Regarding the result of the application of this open-hearth system, it may be said regarding the furnace started in December, 1910, that it has been in steady work ever since completion and that it worked well from the very start, although some minor changes, principally in the flues and in the mechanical parts such as reversing valves, gas-main valve, and others, have been made later. With this furnace it has been the custom to take off only one heat of two and a half to three tons a day and to shut the furnace down from afternoon until next morning as well as over Sundays, and this without in any way damaging the brickwork, which has needed repair only once a year, and this only in the wall on the tapping-side and around the doors and ports.

The furnace which was started in the beginning of 1912, has been melting from two to three heats a day and the trials made have been very exhaustive. Both steel, grey iron, and white iron (for malleable purposes) heats have been taken off directly after each other within the twenty-four hours without any trouble. The quality of the product has in each case been very good and the furnace has shown a remarkable adaptability for different kinds of service.

Regarding the time required for the melting of a charge, a normal heat of two and a half to three tons of 2,200 lbs. of white iron requires, including the charging, about two and a half hours, although even three hours have been necessary when unsuitable irons were used, when the charging was not done properly or when the gas was poor. The iron is obtained very hot and the control of the flame is so perfect that the oxidation is kept very low; in fact, cases have been noted where the reduction in silicon has been next to nothing. On the other hand, when occasion has arisen, as in trying new mixtures where the silicon content has been held rather high in the charge, the

* Abstract of Paper presented before the American Foundrymen's Association at the Annual Convention, Buffalo, 1912.

oxidation has been carried on as required. The time required for bringing down a heat of about three tons of grey iron is about two hours, while rather smaller heats have been charged and melted in about one and a half hours. Although the normal capacity of the furnace is two and a half to three tons, charges as large as four and three-quarter tons have been successfully melted.

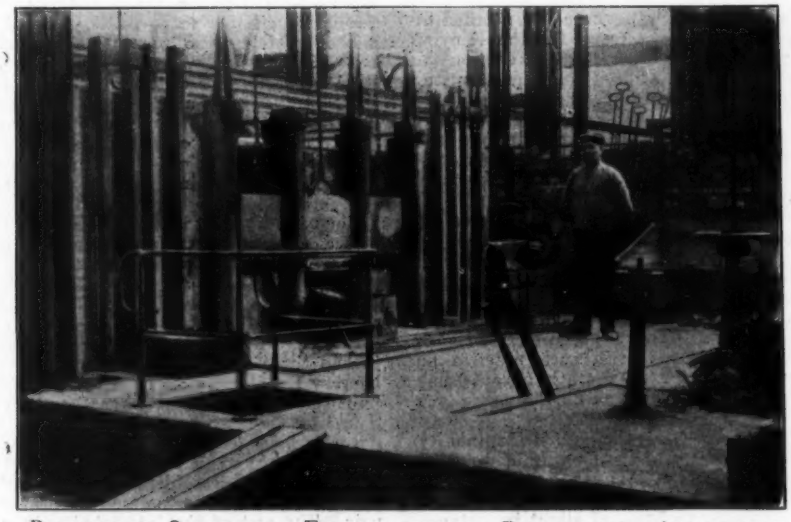
Comparison of Air-Furnace and Open-Hearth Systems.

In considering the time required for the melting and the raising to pouring heat of a given charge, it should be borne in mind that the time needed for a ten-ton charge in a ten-ton furnace is practically the same as for a three-ton heat in a three-ton furnace, so that it is not right to compare the melting time of unequal charges in different sized furnaces.

In considering the fuel consumption in melting iron it must be remembered that the open-hearth furnace requires continuous service; as it is lined with silica brick it must be kept heated at all times. To obtain a high heat in the hearth the checker work must be kept hot. Therefore, whether used or not used during the whole of the twenty-four hours, fuel is constantly being consumed, although at a slower rate when the furnace is not melting. The normal fuel consumption with coal in Swedish open-hearth steel practice is 25 to 26 per cent. of the weight of steel produced, while running steadily with three heats in twenty-four hours. The author's experience during the last six months with the open-hearth furnace in malleable practice has been that the fuel consumption for the entire process of melting, annealing and core baking has amounted to one pound of coal for every pound of finished malleable castings; but it should be mentioned that the coal used was a very poor quality of German coal with a large percentage of slack. It should furthermore be borne in mind that the furnace has been used during the night only exceptionally and that therefore considerable fuel has been required to raise the temperature of the checker brick in the regenerators and of the furnace proper to the necessary point before charging in the morning. There seems to be no doubt of the possibility of reducing the fuel consumption for melting white iron to a maximum of about 18 per cent. if the furnace is worked more steadily, *i.e.*, taking off four heats during the day, and to still less if continuous melting can be carried on.

After each tapping the breast is broken up, the remaining slag drawn out and the bottom patched up, if needed, with some quartz; the breast is again filled in with old moulding sand, and a short sand plug rammed in, whereupon the furnace is ready for the next heat. The time required for this work takes from twenty to thirty minutes.

As all malleable men know, the quicker the melting is done in the furnace, the better the iron, and similarly the more the composition of the metal remains unchanged, the better the result. A slow and irregular melting in a furnace which is working poorly will do more to ruin the iron than will any other part of the process. A quickly and correctly melted iron of the right composition will suffer little damage in the annealing furnace even if the heat is irregular, but then again even a slight tendency to undue oxidation of the bath in the melting furnace will give a poor product. To melt right, two things are needed: a properly constructed furnace and a skilful melter. Doubtless it is the lack of one or of both of these prime conditions which has been responsible for the failures recorded with some open-hearth furnaces. In the malleable-iron foundry this furnace is purely a melting machine, and it should be constructed with that end in view, and also be handled as such.



PLATFORM OF OPEN-HEARTH FURNACE SHOWING DOOR-HOISTING ARRANGEMENT.

Advantages of the Open-Hearth Furnace.

The open-hearth furnace melts iron for less fuel expense than the air furnace; the iron can be overheated to a higher degree and therefore distributed in larger quantities to the moulding floors, with the advantage of reduced labour for the moulders while pouring as well as a quicker emptying of the furnace, which gives a more uniform, homogeneous metal; the melting is done quicker and the control of the flame is far more exact, so that the changes in the chemical composition of the bath can be reduced to a minimum and all danger of undue oxidation avoided. Shrinkage of the iron is less, the iron stronger and the required annealing temperature lower. Through the lessened oxidation of the bath the slag is less in quantity and the melting loss of iron reduced.

The open-hearth furnace, when skilfully managed,

is always reliable, the time required for melting a given charge being regularly the same. The quality of the iron tapped is also perfectly uniform, since the possibility of careful regulation is greater than in the air furnace. Mechanical appliances can be used for charging and operating the producers and no coal shovelling and very little slag handling is required. The charging of the furnace is very quickly done direct from the working platform and can be done by means of charging machines. The open-hearth furnace is cleaner than the air furnace, as no smoke is seen in the foundry, no dirt or ashes need be taken care of, there is little in the way of slag skimmings off the bath, and the furnace performs its work noiselessly.

The combustion is very efficient in the furnace and the smoke-stack temperature low. The open-hearth furnace requires very much less space on the floor than the air furnace of the same capacity, and by setting the furnace low the tapping can be done, if desired, in small hand ladles in the same manner as with air furnaces. Furthermore, the frequently recurring repairs and broken-down bungs in an air furnace are reduced to a shut-down about once a year, occupying about ten days. The cost of repairs both in labour and material is thus reduced to a minimum. In the air furnace the sand bottom must be relaid at least once every week and be patched between times; there is no necessity for the relaying of an open-hearth bottom other than in conjunction with the yearly repairing, while a slight patching up once in a while is all that is required.

One of the greatest advantages of the open-hearth system is the possibility of obtaining a greater output with a smaller furnace as compared with air furnaces. It is very easy to take off four heats in twelve hours, while three is the maximum number in air-furnace practice if no overtime is resorted to. If, again, work in shifts is arranged so that the furnace can run steadily during the whole twenty-four hours, then the output can be vastly increased. If gas, the open-hearth firing, is also used for other kinds of furnaces, a large saving will be effected in labour as well as in fuel. This has been clearly shown in the author's experience; with such practice no heat is at any time wasted, as there is always some one of the furnaces in operation on the same gas main.

Finally may be mentioned the great adaptability of the open-hearth furnace to the melting of different kinds of material, as it can be used to equal advantage for not only white iron, but also for grey iron and for steel. This is, perhaps, of slight importance in a foundry in which nothing but malleable castings is being made, but in the author's experience this general usefulness of the open-hearth furnace has been a most valuable asset to the plant, when the demand for malleable-iron castings at times was limited, but not to such an extent as to involve shutting down.

As against the foregoing are the possible drawbacks which must be considered when comparing the air-furnace and open-hearth systems. These are the higher first cost of building, the possible difficulty of finding competent melters and the desirability of working the furnace continuously. So far as the higher cost of construction is concerned, many circumstances have to be weighed in judging this matter, because the local conditions have their influence, as well as the kind of fuel to be used, the relative cost of silica brick as compared with fire-brick, etc. But one must bear in mind that the same gas plant can furnish fuel also for annealing furnaces and for core ovens; that the capacity of an open-hearth furnace can be made very much less than that of an air furnace for the same daily output, and also that the same chimney can be built to serve all furnaces if these are suitably placed. The increase in the cost of construction will, when everything is taken into consideration, be only such that the reduction in the cost of repairs, apart from other advantages, will pay the interest on the bigger outlay in first cost.

Advantage of Continuous Operation.

As regards running the furnace continuously, this is desirable if the greatest profit is to be gained; but nevertheless an installation will be profitable even if no heats are taken off during the night. Especially will this be the case if the annealing furnaces take gas from the same producer plant, when a small portion of the gas can be used in the melting furnace to prevent the heat in the regenerators from dropping too low. In that way the cost of keeping the furnace under fire at night will be very small and hardly to be reckoned with. Further, the advantages of continuous operation of the foundry are from other standpoints so great that it should be a goal towards which all the malleable-iron founders should work. For a given output, the foundry proper can be built very much smaller and the melting furnaces need not be nearly so large as is the case with a nine- or ten-hour a day place. From a three-ton open-hearth furnace there can be taken during twenty-four hours seven heats, without difficulty and without forcing the plant; this equals twenty-one tons of metal a day, or during a year of 290 working days (allowing the time for repairs), in round numbers 6,000 tons, making say, 3,000 tons of finished castings, or equal to a ten-ton a day plant. The difference in cost between a three-ton open-hearth furnace and an eight- to ten-ton air furnace is, taking everything into consideration, not very great and certainly not so great that it should be a serious hindrance to taking the forward step.

The continuously working foundry will run with less over-head charges per pound of castings than the other plant, the cost of production will be less and the returns on the capital invested should be greater. A continuous foundry will reach a higher efficiency and will stand a very much smaller chance of losses in bad times, as it will, if cut to half of its output, be very little worse off than the foundries which are built for day work only, when these are running full.

Cost of Furnace Construction.

Next may be considered the cost of building of open-hearth furnaces, as well as of their yearly repair. The cost of the latest built three-ton furnace, above referred to, has amounted in round figures to £1,400. This includes two gas producers and all flues for gas, air and smoke, one blower with 25-h.p. electric motor, charging platform and accessories for the producers, the large concrete foundation pit before mentioned, and all foundations, together with a 100 ft. stack of radial brick construction, which gives more than enough draft for two annealing furnaces, the open-hearth, one core oven and two brass furnaces.

To give a clearer idea of the comparative cost, it should also be said here that good fire-brick 9 by 4½ by 2½ in. cost £5 12s. a thousand, 12 by 6 by 3 in. £7 5s. per thousand, 9 in. silica bricks £9, and 12 in. silica bricks £12 per thousand. Crushed quartz costs £1 10s. per ton of 2,200 lbs. and good so-called Dutch white clay £1 6s. per ton. A mason gets 6s. a day, but does no more than one quarter of the work that a good American mason will do. An unskilled labourer gets 3s. 9d. a day. The structural steel and plate work entering into the construction was figured at £25 13s. 6d. a ton, and the cast iron at £12 16s. The amount of crushed quartz sufficient for one year's run can be taken as ten tons and the

cost of labour and material for the big repair once a year, together with fuel for reheating, can safely be put at a maximum of £80. Of course, if steel is made the question of repair cost will take a different aspect, but that item should not in any case run over £120 to £160 per annum.

Quality of Product and Annealing Requirements.

In making a true comparison between the systems of melting iron for malleable purposes in open-hearth and in air furnaces or cupolas, in addition to the cost of the melting operations, interest, depreciation, repairs, fuel consumption, cost of labour, etc., must also be carefully considered the quality of the metal and how it turns out in the annealing operation. In this matter the open-hearth compares very favourably with all other kinds of melting systems in use. As far as the cupola metal is concerned, the author has very emphatically confirmed the fact that cupola metal requires higher heat and longer anneal than does metal melted in open furnaces of all kinds. One mixture required, when melted in the cupola, fully 1,825 deg. Fahr. to 1,900 deg. Fahr. during 96 hours, while if melted in the open-hearth, 1,650 deg. Fahr. during 12 hours or 1,450 deg. Fahr. during 60 hours was enough. Furthermore, to get a good black-heart fracture from the cupola metal was practically impossible, while no difficulties were met with when the open-hearth metal was treated. Malleable men will probably feel inclined to say that no such annealing temperature as 1,450 to 1,650 deg. Fahr. is needed in American practice to get the very best black-heart fracture, and such a criticism would be quite justified. The reason for using that comparatively high temperature will be explained in conjunction with references to sulphur. However, not only against the cupola-melted white iron but also compared with air-furnace metal, the author has proved the superiority of the open-hearth iron.

A certain Cumberland hematite pig-iron has been used by the author for several years in air-furnace practice with good results, it being especially easy to anneal compared with previously used Swedish brands, but it was necessary at all times to mix that iron with others in order to raise the silicon and phosphorus, because the oxidation of the former in the air furnace as a rule reduced the silicon too much in the bath, while the fluidity suffered from lack of phosphorus. The analysis of the pig-iron in question is as follows: Si. 0.90 to 1.00 per cent., S. 0.025 per cent, P. 0.020 per cent., Mn. 0.40 to 0.60 per cent. The proper annealing heat for this iron, melted in air-furnace, was 1,425 deg. Fahr. during 72 hours full heat. When this very same iron was used later in an open-hearth furnace it soon showed its superiority to other brands previously tried, and although it was used together with the white scrap from previous heats, without adding any other kind of pig, the result was and is continuously a fine, fluid and hot metal, which shows only very slight reduction of the silicon during the melting and which is sufficiently hot to run well even with the low phosphorus given above. Even in the anneal this iron shows up better than when melted in the air furnace; it gives a fine, strong black-heart casting after annealing at 1,325 to 1,375 deg. Fahr. during 65 to 70 hours.

At the plant where the new foundry and the open-hearth installation above referred to were built, malleable cast iron had for several years been made according to the Réaumur method by melting in a cupola and annealing at 1,825 to 1,900 deg. Fahr. during a period of fully 96 to 120 hours of full heat. The fracture of the annealed castings was steely. The pig-iron used was of English make and of two kinds, the one grey and the other white. The former analysed 1.97 per cent. silicon, the latter 0.45 per cent., while the sulphur ran from 0.18 to 0.25 per cent. The mixture was made up of both these kinds of pig-iron, a large percentage of wrought iron and steel scrap and the foundry's own hard scrap. When the new melting and annealing installation in the newly built foundry was ready, a stock of the above-mentioned high-sulphur pig-irons remained unused. Attempts were made to use these high-sulphur irons, and the charges were made up of these together with the hard scrap in suitable proportions. The iron did not turn out altogether satisfactory in the furnace and was slow in getting up to pouring heat, but could be used very well. The annealing temperature at first tried was 1,650 deg. Fahr. during 80 hours, and when this showed over-anneal, it was kept at 1,650 deg. Fahr. only about twelve hours, and then gradually dropped to 1,450 deg. Fahr., where it remained for 60 hours and gave a good and strong casting with black-heart but of a decidedly greyish tint. The analysis of the castings showed :— Si, 0.80 per cent., S, 0.22 per cent. Mn, 0.20 per cent., and P, 0.10 per cent. In the same annealing ovens some castings from previous cupola melts were also introduced, but after having been in the furnace twice they still remained glass-hard. The analysis showed Si, 0.45 to 0.60 per cent., and S, 0.26 per cent.

Effect of High Sulphur.

Since two different trial lots of English hematite malleable pig-irons, both analysing Si, 1.00 per cent., S, 0.03 per cent., Mn, 0.40 per cent. and P, 0.04 per cent., had been obtained, mixtures were made up of them and some of the old high-sulphur pig, in order to work up the stock as soon as possible. While the silicon in that way was brought down to 0.10 to 0.12 per cent. or thereabout, the annealing temperature could be dropped to a maximum of 1,450 deg. Fahr. during 72 to 78 hours, and the fracture was still black-heart, but a trifle grayish, while the strength and malleability were well up to standard. Castings from mixtures containing no high-sulphur pig, but only either of the above mentioned hematite pig-irons and white scrap, and annealed together with the castings containing 0.10 per cent. sulphur, showed decided over-anneal and gave better results with temperatures around 1,375 to 1,425 deg. Fahr. during 72 hours.

The author's experience as related above seems to show that sulphur is not dangerous in malleable castings, even if they are to be black-heart, but that the required annealing temperature must be increased with higher sulphur. The commonly recognised influence of sulphur in cast iron is that it increases the hardness and makes the fracture dense, wherefore it is a desirable element in such castings as for instance cylinders. It seems, therefore, but fair to surmise that the influence of sulphur in white iron is similar and that the higher annealing temperature required is caused by the destiny of the structure, *i.e.*, the closeness of the molecules in the iron to each other. In a similar way it seems possible to explain the fact that certain brands of iron, although the chemical analysis may lie within the limits commonly recognised for good malleable pig-iron, need higher annealing temperatures than others. This, for example, is the case with the Swedish charcoal irons, in which the fracture as a rule is very dense and the strength high. Similar to the influence of sulphur seems to be that of manganese and the effect on the hardness of cast iron is the same. It is also certain that the annealing of white iron with too high manganese is extremely difficult if not altogether impossible.

Distinction between Reaumur and Black-Heart Castings.

In the English or American literature on malleable cast iron the author has not been able to find any

fully acceptable explanation of the differences between the black-heart malleable and the Réaumur malleable, *i.e.*, the malleable with steely fracture. As far as he has followed the few opinions given, it seems that the American experts put the matter to one side simply with the explanation that in the manufacture of black-heart malleable the annealing—or decarbonising process—is stopped as soon as the surface of the casting is decarbonised and the carbon in the interior converted into temper carbon. In the Réaumur process, on the other hand, it is said the decarbonising process is carried further until all the temper carbon is gone and what remains of carbon is in the combined form, while the fracture of the casting is steely and of an even colour right through. In the author's opinion that is only half of the truth, as there is certainly a little more behind the difference than just the annealing temperature and time for annealing.

While experimenting with different brands of malleable pig-iron in open-hearth and air-furnace practice during the last seven years or more, the author has had ample opportunity of demonstrating that some brands of pig-iron are more suitable for malleable practice than others of similar composition. For instance, the two brands of English-made malleable pig-iron from hematite ore, previously referred to, showed fairly good results; the iron melted quickly and "took heat" reasonably soon after the bath had been skimmed once. The analysis of these irons is: Si, 1 per cent., S, 0.03 per cent., Mn, 0.40 per cent., P, 0.04 per cent. When these brands, however, were compared with the Cumberland hematite pig-iron referred to previously the difference in favour of the latter was very marked. The analysis of this latter brand is: Si, 0.930 per cent., S, 0.025 per cent., Mn, 0.450 per cent., P, 0.020 per cent., or so very near the same as the others that the chemical composition cannot be responsible for the difference, but probably rather the ore from which the iron is made and the manner in which it is made.

One final instance may illustrate the adaptability of the open-hearth furnace. It had long been the author's desire to in some way use the old burnt annealing pots in the foundry work instead of burying them or, if fortunate, selling them to a dealer. Previous attempts to melt in a cupola the very much burnt iron together with common soft foundry pig-iron have not turned out well, but in the open-hearth furnace this is done with good results, and an iron good enough for common purposes is obtained. In this case the pig-iron, as high as possible in silicon, is first melted and then the pot scrap added in such proportions as the bath will stand.

Physical Properties of Cast Iron.

Before the Halifax and District Branch of the British Foundrymen's Association, on Saturday, November 23, a Paper was read by Mr. F. J. Cook, of Birmingham, on "The Physical Properties of Cast Iron." The President (Mr. Hugh Campbell) was in the chair.

Mr. Cook's lecture was illustrated by micrographs showing the effect of structure on the ultimate strength of castings. Examples of test bars were shown, which although of practically the same chemical composition, varied 100 per cent. in tensile strength. Chilled and unchilled bars were described and their relative hardness explained. A chart showing the effect of blast pressure on cast iron was particularly interesting. From a long series of experiments, it was shown that as the blast pressure varied from 2 ozs. to 12 ozs., so the tensile and transverse strength of the resulting iron was increased, but beyond that pressure a decrease of strength was obtained, until with a blast pressure of 24 ozs. it had dropped back again to practically the same as at 2-oz. pressure. The hardness tests, however, showed a constant increase and were greatest at the 24-oz. pressure.

The use of micrographical investigation was illustrated by the case of a cylinder which had proved defective. Over 200 micrographs were taken from different parts of the casting, by which it was proved that it was the design and not the material which was responsible for the defect. A number of photographs showing moulds for large castings in the different stages of construction were also exhibited, one having a core which weighed over 30 tons.

The PRESIDENT, in opening the discussion, described the lecture as one of applied science. He would like to know if any great difference was found in testing annealed bars as against bars as cast; also would Mr. Cook state whether or not they annealed the engine cylinders and pistons at the works with which he was connected.

Mr. CARRICK remarked that some of the lecturer's statements would appear almost phenomenal; he had proved that the use of chills produced quite an opposite effect in hardness tests to that expected, the chilled iron proving the easier to drill. His (Mr. Carrick's) explanation was that the true use of chills was not to produce hardness but to prevent segregation—not really to chill, but to cause quick cooling in the thick sections. It was quite possible to place the chill so as to give quick cooling and obtain carbon in a finely divided state, similar to that obtained by annealing. This might not show any more combined carbon even in castings where the silicon did not vary. The chief advantage of the drill test was that it gave a relative idea as to hardness from day to day. With regard to blast pressure, which was Mr. Cook's pet theory, unless it was absolutely controlled, it was rather a dangerous plan to work on. He much preferred to work on the use of silicon, and regulate the iron after it had come down, according to the work laid on the floor.

Mr. ROBINSON, with respect to hardness tests, which were referred to according to certain numerals, asked how were the numerals obtained? Was there a definite standard ranging, say, from the hardness of a diamond down to a soft lead, or had each special apparatus a scale of its own?

Mr. STACEY asked if the tests spoken of could be applied in the same way to either green-sand or dry-sand castings?

Mr. E. W. SMITH said he could not quite understand chilled test bars being softer than unchilled and showing hardness tests of 53 and 60 respectively, especially as Mr. Cook said that the hardest bars were not always the most difficult bars to penetrate. It did not, therefore, follow that the chilled bar has the most combined carbon. What percentage of combined carbon gave the maximum test? Mr. Cook had told them in his lecture that the larger the network structure the greater the strength. Previously he had generally accepted the idea that the smaller the structure the greater the strength, and the two theories presented opposites to him. From a set of test bars cast from the same metal, Mr. Robinson supplied samples for the use of the students at the Technical College which varied in transverse

strength from 34 to 37 cwts., and on examination of the structure under the microscope they could find very little variation.

Mr. Robinson said Mr. Cook had given his hearers to understand that 19.2 tons tensile strength practically established a record for tests taken in this country. In the work with which he was connected, he was reaching the satisfactory mark of 19.25 tons tensile strength.

Mr. Campbell corroborated this statement, and said he felt, after the remarks given this afternoon, that they had every reason to feel proud; but he was given to understand that in Germany they were getting 20 tons tensile strength, and he would like to know if Mr. Cook could verify the statement.

Mr. Cook, in his reply, said he had practically no experience in testing annealed bars, but he should not expect any great increase in the strength of bars with annealing. They did not anneal their cylinders and pistons. Mr. Carrick had drawn his attention to the term chilling iron, and had called it a misnomer. He quite agreed and said it was time a definition was come to with respect to chills. His own suggestion would be "a grey chill" and "a white chill." The use of chills was not in every case actually to chill the iron, but to so regulate its solidifying as to prevent segregations. If the chills placed in cylinders caused a white chill they could not be machined. In using chills, the thickness and composition of the metal had to be given careful consideration. Manganese had a great tendency to chill; but despite Mr. Turner's suggestion that even in small quantities sulphur tends to harden the metal, his own examination suggested that sulphur had nothing to do with it. For a grey chill they must keep the manganese under 0.5 and for a white chill over 0.5. For cast iron he (the lecturer) favoured the drill method of testing, from a works point of view, as it was not a test for face hardness that was required, but an even solidarity throughout. There was no standard of hardness at the present time. With given conditions the same diameter of test bars was always cast, but results could only be comparative. Another point to remember was the angle of the drill; he always relieved the point by drilling an $\frac{1}{4}$-in. hole before making the test. Where it was a common occurrence at their own works 10 years ago to get variations of 100 per cent. from one day to another, it was now an exceptional thing to get a 10 per cent. difference. With respect to the preference for silicon as against the regulation of the iron by blast pressure, it was absolutely essential that one should have complete control. They had on their cupola a variable-speed motor and also a blast indicator to show the amount of pressure not only at the moment, but right throughout the blow. This gave a record which no furnace-man could contradict. There was also volume as well as pressure to take into account, and they had each to find out what was most suitable for their own cupola. He got the best results with a 12-oz. blast pressure, but only by experience could the best results be obtained from any particular cupola. Bars cast in dry sand and green sand would certainly vary according as the rate of cooling was affected. The bars he had spoken of were all cast in dry sand. Bars cast in green sand would certainly be the hardest, as the moisture acted as a chill and increased the rate of cooling. This raised the question of the relative hardness and strength of machined and unmachined test bars, 1 in. diameter. The unmachined bar would be the stronger because $\frac{1}{8}$ in. was allowed for machining, this necessitating 1$\frac{1}{4}$-in. bars being cast and the rate of cooling being affected. With regard to the network structure of iron, he quite recognised the gain to be had from finely divided graphite, but the peculiar point was that in all strong sections shown there had been that particular net-like formation as well, and small graphite was not got without it. It was only when examining under low magnifications and after deep etching that the network formation was seen. With regard to the test bars supplied for the use of the College students, they could not expect to find much variation in structure, these showing a difference of only 9 per cent.; he had been dealing with bars varying 100 per cent.

The meeting concluded with a hearty vote of thanks to Mr. Cook for his instructive lecture.

Close-Grained Soft Cast Iron.*

By J. J. Porter.

There is a growing demand for cast iron of special properties, and users are becoming educated to the point of demanding castings not only outwardly perfect, but also of material exactly suited to their needs. A case in point is the demand among machinery builders, and especially machine-tool makers, for castings close-grained and capable of taking a high polish, and at the same time soft and easily machined. A close-grained iron polishes to a white steely surface, very pleasing to the eye, and free from graphite lines except on very close inspection. An open-grained iron absorbs oil and dirt, and becomes darker, while the close-grained iron, by simply wiping off, is restored to its original whiteness. Machine-tool builders take great pains with the appearance of their product, and use polished surfaces very freely. At the same time, they are not, as a rule, willing to sacrifice cheapness of production as represented by ease of machining. Hence the demand has been loud and insistent for the combination of close grain and softness, and in some cases such castings will command considerably higher prices.

We are accustomed to think of these two properties as being incompatible. To a certain extent, this is true, the closest grain going with a very hard iron; but it is also true that for any given degree of hardness there is a wide range in the possible grain structure.

The subject is a rather difficult one to study, largely because of the lack of means for definitely measuring and recording grain size. Very little is known as to the real cause of differences in grain structure, but the controlling factor in grain size is, no doubt, the size of the flakes of graphite, their distribution and number. Other subordinate factors, if any, are obscure, and poorly understood. The whiteness of iron as shown on its polished surface is not strictly in proportion to its closeness of grain, but as a general rule, the two things go together. A desirable iron must, therefore, have a limited amount of graphite, in small flakes and uniformly distributed.

Coming now to practical means of controlling graphite, grain sizes and hardness, I have classified these under the following heads:—(1) Chemical composition; (2) use of steel scrap, chips, etc.; (3) selection of kind of iron and brands; (4) use of alloys; (5) control of rate of cooling; (6) cupola practice; (7) practice in machining.

Chemical Composition.

The most important element is silicon, which should be kept just as low as possible without hardening the iron too much. Most foundrymen carry an excess of silicon in order to be on the safe side in the matter of hardness, and this can usually be considerably cut down, provided the mixture is under close chemical control.

* Presented before the Buffalo Convention of the American Foundrymen's Association.

Sulphur will close the grain if in excessive amount, but only at the cost of hardness, and probably other troubles. Personally the writer does not consider it a safe means to use.

Manganese is ordinarily supposed to have an important influence in closing grain, but the writer is rather doubtful as to its efficiency. In moderate amounts it probably has some good effect, but an excessive quantity will not only harden, but may actually open the grain, due to the formation of large crystals of manganese carbide.

Phosphorus, within the usual limits, probably has little or no effect on either grain size or hardness.

Use of Steel or Chips in the Mixture.

The use of steel scrap and the making of the so-called semi-steel is becoming very common, and where properly handled it is an excellent means of closing grain and increasing strength. Ten to 25 per cent. is generally used, and if silicon is properly regulated the hardness will not be materially increased. Of course, the good effects of steel may be nullified by cupola troubles incidental to its use, and the necessity of special precautions when charging it is now generally recognised.

The addition of chips to the charge also has a strong tendency to close the grain, but in this case again precautions must be taken to avoid oxidation and cupola troubles. It is very difficult to understand thoroughly the action of steel and chips in closing the grain. In part it is, no doubt, due to decrease in the amount of carbon (and graphite) in the casting, but it cannot be all attributed to this cause, as in many cases analyses show the close-grained iron to be quite high in carbon, due, of course, to absorption in the cupola.

Selection of Kind of Iron and Brand.

Charcoal iron, if properly used, will give much closer-grained castings than coke iron of equal hardness. There is also a considerable difference in the behaviour of different irons of the same class, some brands giving better results than others. Apparently the difference is due to variations in furnace practice and material used, but no definite rules can be given, and the best brands can only be found by experience.

Use of Alloys.

The sellers of certain foundry alloys claim among other things that their addition will close the grain. The writer has experimented somewhat along this line, but without getting any very marked results. The use of either titanium or vanadium alloy seemed to give more uniform and possibly a little closer grain structure, but these results would probably have been more pronounced on a poorer grade of iron.

Control of Rate of Cooling.

It is well known that rapid cooling gives smaller grain size and greater hardness. It is common practice to use chills to form the Vees of lathe beds, the size of the chills being so proportioned as to decidedly close the grain, and yet not actually chill the iron and make it very difficult or impossible to machine. Cores are also used in some cases where they are not otherwise necessary, on account of their cooling power and to close the grain.

Within recent years it has been discovered that cast iron may be made close-grained by cooling rapidly through its solidifying temperature and just below, and at the same time soft by cooling slowly through the lower range. This principle is applied in processes of casting in permanent moulds. Castings can be made considerably softer by allowing them to remain in the sand until cold, and thus anneal themselves. Since slow cooling through the lower range of temperature probably does not effect the grain size, it follows that a combination of low silicon and prolonged cooling is useful in getting the desired properties of softness and close grain.

Cupola Practice.

Bad cupola work is capable of nullifying the effects of almost all of the methods suggested for reducing grain size. It may also produce close grain in combination with hardness through excessive oxidation. It is thought by some that the rate of blowing and blast pressure have a good deal to do with the grain structure of the iron, and it is certainly true that the height of the melting zone and coke bed is, in some cases at least, an important factor. The higher the melting zone and the longer the column of coke through which the iron trickles, the greater the tendency to open grain.

Practice in Machining.

It is known to most machinists, but not to all foundrymen, that a good close-grained iron can be made to appear open-grained by machining. A heavy roughing cut will pull and tear the iron crystals, and for a short distance below the surface produce a very open structure. If now the finishing cut is very light, or if the finish follows directly on the roughing cut, the iron will appear very open-grained, while with proper treatment it may be entirely satisfactory.

The writer has purposely avoided going into theory in this Paper, but to those who are interested in reasons is recommended a recent Paper by E. Adamson.* In this Paper evidence is given to show that several forms of graphite exist, varying considerably in their behaviour during the melting and solidification of the iron. This fact is probably competent to explain most of the differences existing between coke and charcoal pig, and between different brands of iron, as well as some of the peculiar effects of steel scrap in the cupola.

At the Northampton Polytechnic Institute, St. John Street, Clerkenwell, E.C., on December 6, the annual prize distribution and students' conversazione was held, when the Marquess of Northampton, K.G., distributed the prizes and certificates. The conversazione for members and students was continued on Saturday, December 7, when the building was thrown open to the whole of the members and students and their friends.

Acid Resisting Alloys.

According to "Metallurgie," an alloy which is said to have great resistance to the influence of sulphuric acid cyanide solutions and similar chemicals, is composed of 92 per cent. aluminium, 2 per cent. bismuth, 5 per cent. copper, and 1 per cent. silicon. These metals are melted in a crucible and molten aluminium added to complete the alloy. Attempts were also made to obtain an iron alloy with great chemical resistance and at the same time soft enough to be worked. Iron-chromium alloys with a very small carbon content were used. The alloy contained more than 10 per cent. chromium, and was refined by adding 2 to 5 per cent. molybdenum. Tests proved that an alloy of 60 per cent. chromium, 35 per cent. iron, and 2 to 3 per cent. molybdenum was of great strength, easily worked, and insoluble in nitric acid, chlorides and even in boiling hot *aqua regia*. Vanadium and titanium gave somewhat similar results. Copper alloyed with cobalt and tin also gave excellent results both as regards mechanical treatment and properties, and resistance to acids. The alloys giving the best results had a composition of 80 per cent. copper, 8 per cent. cobalt, 12 per cent. tin, and 95 per cent. copper, 2 per cent. cobalt, and 3 per cent. tin.

* "Temperature Influences on Iron and Carbon," "Jour. Iron and Steel Inst.," No. II, 1911.

Use of Chills to Overcome Liquid Contraction.

At a meeting of the Lancashire Branch of the British Foundrymen's Association, on Saturday, December 7, Mr. F. Penlington presiding, Mr. R. Carrick, of Shipley, read a Paper on "The Use of Chills to Overcome Liquid Contraction." The Paper was as follows :—

Of the many difficulties that every day beset the path of the foundryman, there is probably none that is the source of so much trouble, or productive of so many wasters, as is liquid contraction. At the outset, it will perhaps be advisable to state clearly what we mean by the term "liquid contraction." It is a term of comparatively recent origin, and one that has been objected to in different quarters. The term more generally used and understood is "shrinkage," and yet this has so frequently been used as synonymous with contraction (especially by patternmakers and others outside the foundry) that it was very essential that some distinction be made; and, to my mind, the term "liquid contraction," or, perhaps, better still, "liquid shrinkage," admirably meets the case. As Longmuir and McWilliam say in their book, liquid shrinkage "refers to the gradual lessening in volume of fluid metal as it approaches the solidification point," and although the cause of liquid and solid contraction is exactly the same, the effect is entirely different. It is well known that different brands of iron vary considerably in the amount of liquid contraction, and that it is quite possible by judicious mixing, to reduce it to a minimum. But having done our utmost in this respect, and having consulted the chemist, metallurgist, and foundry expert (and by the way, there is an exceptionally fine field for scientific investigation and research open to these gentlemen)—having done all this, and more, we still find ourselves with numerous problems of leakages, porosity, and spongy places due to liquid contraction.

The use of the feeding rod in the hands of a competent man (and it is surprising what a large number of moulders there are who have very little idea of the proper use of the feeding rod) may do a great deal towards getting a casting sound, but there are scores of cases where it is impossible to get absolute solidity, even with the feeding rod, and there are still more cases where it is impossible to get near the heavy section with a feeding rod at all, and consequently other methods must be adopted, or else the castings must be left in an unsound condition at that point.

Let us now consider some of the well-known cases with which we are all more or less conversant—hubs of spur wheels, blank wheels, flywheels, pulleys, etc. The majority of these are very similar in design, and are jobs that frequently give trouble, owing to not being sound in the hub. Almost without exception these have a large fillet at the point where they connect with the arms or web, and it is at this point where porosity is got. A chill cast in the centre instead of a core is likely to be much more effective than the feeding rod. Further, there is the time saved in feeding, not to mention the energy and vitality of the moulder; and it not infrequently happens that when the moulder has done his utmost with the feeding rod, and has fed it very thoroughly (in the case of fairly heavy hubs) there may still be porosity or sponginess. This may not be entirely due to liquid shrinkage, but is probably due to the carbon separating out in the form of graphite, owing to the slower rate of cooling at this, the thickest section of the casting. This was very clearly brought home to the author in the case of lathe face-plates, which prior to the use of chills had been a real source of trouble in the shop. The hole would appear to be fairly sound when it was bored, the plate would then be turned up, but when the thread came to be cut, it would often crumb and fall away right in the centre of the hole at the root of the thread, the casting being consequently scrapped. A chill effectively cured this and scores have since been made without a single failure; moreover, a much better wearing thread is obtained.

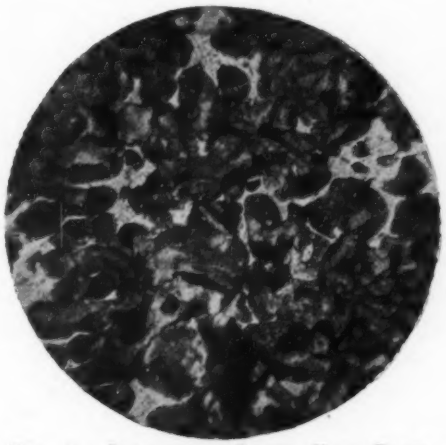


FIG. 1.—SECTION OF LATHE FACE PLATE, CAST WITH CHILL; MAG. 200 DIAM.

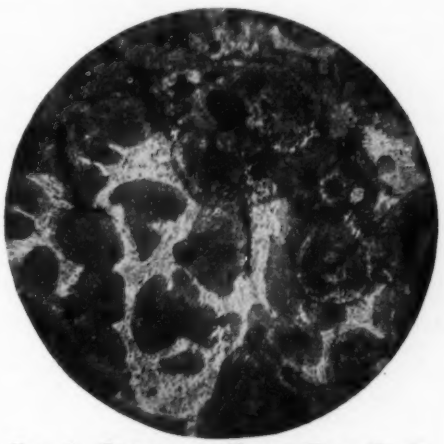


FIG. 2.—SECTION OF LATHE FACE PLATE, CAST WITHOUT CHILL; MAG. 200 DIAM.

Fig. 1 shows a section of a lathe face-plate that has been chilled, and the thread cut; the close structure next to the thread is very clearly seen. Fig. 2 shows another face-plate that has not been chilled, but left with its own green-sand core; the difference in the structure is clearly seen, and needs no explanation. Both these castings were made out of the same mixture of iron, the analysis being approximately:—Total carbon, 3.22 per cent.; graphitic carbon, 2.97 per cent.; combined carbon, 0.25 per cent.; silicon,

2.44 per cent.; sulphur, 0.09 per cent.; phosphorus, 1.23 per cent.; manganese, 0.51 per cent. The physical properties were:—0.147 contraction on a ½-in. square bar 12 in. long; transverse test on 1-in. square bar 12-in. centres, 2,460 lbs., with 0.11 deflection; and a fairly solid structure on the K test. I might add that this mixture was not made specially for the plates, but for a general heat, where there were

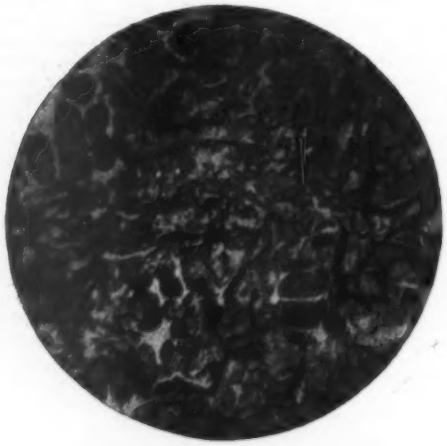


FIG. 3.—WORM GEAR BLANK, CAST WITH CHILL; MAG. 200 DIAM.

hundreds of castings ranging in weights from a few ounces to a ton, and varying in thickness from ¼ in. to 2 in.

Fig. 3 shows a portion of a casting that is used for a worm to gear into a worm wheel. As it is cast it is simply a plain blank 4½ in. diameter 5 in. deep with a ¾-in. core cast in the centre. It has been chilled on the outside in order to get a very solid and close structure, and give a hard wearing surface on the thread, where it gears into the wheel. How well

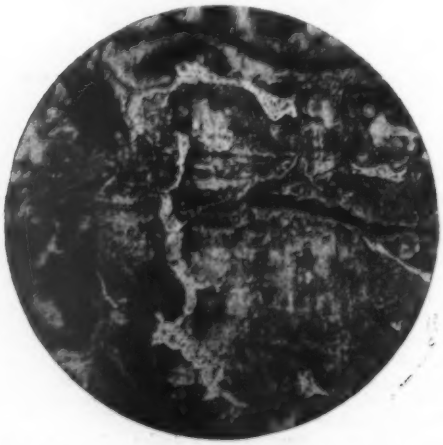


FIG. 4.—WORM GEAR BLANK, CAST WITHOUT CHILL; MAG. 200 DIAM.

this has been accomplished is clearly seen in the illustration. By way of contrast, the next slide, Fig. 4, shows a similar casting cast in the ordinary way in a sand mould, and fed with the rod. The difference in the two is very marked, the one made in the chill being infinitely better for the work it has to do, than the one made in the ordinary way.

Fig. 5 shows a part of a casting that is very peculiar in design. The part from which this illustration is taken is about 1½ in. by 2¼ in. thick; it is formed in a core, and is in such a position in the casting that it is impossible to feed it properly, having a web of metal about ½ in. thick immediately above it. Being in the centre of the casting, and formed in the core, a very slow rate of cooling was got, and absolute solidity (which was very vital to the strength of the casting) was out of the question. Too small chills ½ in. thick rammed up in the core, one on each side, effectively cured this. The illustration gives an idea of the fine homogenous structure obtained.

Fig. 6 shows a companion casting without the chills. Note the open structure and the large flakes of graphite, which are clearly due to the very slow rate of cooling.

Fig. 7 is a section taken from a casting that is 4 ft. long and 3½ in. to 4 in. thick all through. About 1 in. from the top are cast some narrow cores, not unlike the port cores of an ordinary steam cylinder. Chills are rammed up in these, and left flush with the face of the core. Tee slots have to be machined

FIG. 5.—PORTION OF A CASTING BELOW A THIN WEB, CAST WITH CHILL; MAG. 200 DIAM.

out of the thick part of these castings, and consequently it is necessary that they should be fairly close and solid. They are cast in a fairly close-grained iron showing about the following analysis:—Total carbon, 3.10 per cent.; graphitic carbon, 2.40 per cent.; combined carbon, 0.70 per cent.; silicon, 1.30 per cent.; sulphur, 0.09 per cent.; phosphorus, 1.21 per cent.; manganese, 1.75 per cent. They come out very sound. Chills are cast all over the bottom face, with the exception of the point where the metal from the runner impinges. A fine homogenous structure is obtained throughout the whole of the casting, exactly as that seen in Fig. 7. These chills are removed as soon as the casting has solidified; the reason for this will be given later.

Fig. 8 shows a similar casting without the bottom chills. This showed a rather open structure at the bottom of the tee slot, and was not nearly so sound as the one with the bottom chills.

Steam-, gas- and oil-engine cylinders, valves, engine beds, centrifugal pumps, tee pipes, lathe turrets, and many others, are castings that can be greatly improved by the use of chills.

It must be emphasised that it is not advisable to use inferior iron for the castings mentioned. On the contrary it is of the utmost importance to use the very best iron suitable for the various classes of work referred to. But it is well to remember that even with the best mixtures, where a very slow rate of cooling is got (as is certainly the case in some section of these castings) one is liable to get an open, porous and weak body of metal at that point. If, however, a chill of the correct design and thickness can be got to the thick section, and solidification thereby accelerated, all danger of porosity or sponginess in that casting is likely to be eliminated. Let it be clearly understood, that although these are referred to as chills, the end in view is to avoid chilling in the ordinary sense of the word, but simply to accelerate solidification, and thereby give the carbon less time to separate out in the form of free or graphitic carbon, but more in the combined form, and thereby give a closer, stronger and more solid section than would otherwise be obtained. In reality the term "chill," as here used, and as it is being frequently used every day, is a misnomer, and unfortunately not only does it convey a wrong impression generally, but especially does it create a feeling of suspicion in the mind of the employer and the foreman machinist.

FIG. 6.—SAME AS FIG. 5, BUT CAST WITHOUT CHILL; MAG. 200 DIAM.

They naturally associate the term "chill" with extreme hardness, and are immediately on the look out for trouble; even if they do not always find it, they have a ready excuse for excess time in machining. As foundrymen we can hardly blame them, for they are simply interpreting the word in its real sense. The remedy for this lies with ourselves; *i.e.*, change the term. Mr. F. J. Cook, of Birmingham, has suggested the use of the terms "Grey Chill" and "White Chill," but while this might meet the case with foundrymen, it would be hardly likely to get over the prejudice in the machine shop. I suggest that this question be dealt with by our B.F.A. Council at their next meeting, and a committee be appointed to devise a suitable term that will convey to all associated with the foundry the correct idea.

As previously stated, in certain cases it is our practise to remove the chill as soon as the casting has solidified. The writer has also expressly stated that the object of the chill is to cause the casting to solidify more rapidly than it would under ordinary conditions. When the casting has solidified, the object of the chill is accomplished, and to leave it on is simply to make the casting harder than is necessary, and thereby cause increased cost in machining. If removed, however, and the casting allowed to cool under normal conditions, there will be little fear of any complaints about extreme hardness. The writer is using hundreds of chills every day, and seldom has a complaint concerning hardness. That is not to say that the iron is not harder than it would be if an ordinary core had been used instead of a

FIG. 7.—PORTION OF A THICK CASTING, CAST WITH CHILLS; MAG. 200 DIAM.

chill; it would be impossible to have the same degree of softness with so much more combined carbon than would ordinarily be got, but the writer does affirm that with proper manipulation of the chills, and with the annealing effect of the heat in the casting, it is quite possible to get them perfectly solid and not too hard to machine.

The ordinary round chills employed are made in both cast iron and steel. For standard sizes which are in use almost every day, a chill or permanent mould is used, in which they are cast. About 3/16 in. of taper on 6 in. is allowed. The method of

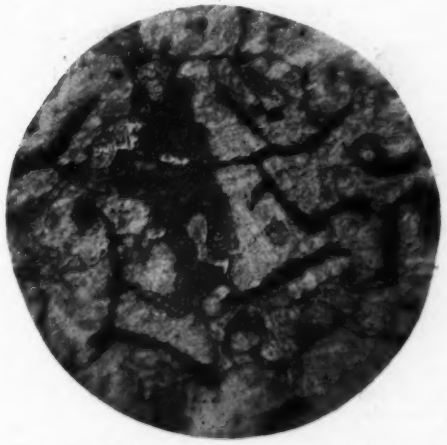


FIG. 8.—SAME AS FIG. 7, BUT WITHOUT CHILLS; MAG. 200 DIAM.

making the patterns for them is to build a clay mould as near as possible to the desired shape, then pour it with plaster of Paris. After it is set it can be carved into the desired shape to make it carry in the sand.

Regarding the removal of the chills, it is not our general practice to take all of them away immediately the casting has solidified, but only in cases where they are deemed likely to cause extreme hardness if left until the casting becomes cold. It would hardly be possible to enumerate the various cases where it is necessary to remove the chills; this is a matter for individual observation and experience, and judicious handling of the chills along these lines is very vital. The writer does not wish the previous sentence to convey the idea that there are cases where it is necessary to leave the chill until the casting is cold; in all cases where the only object is to prevent segregation by causing quick solidification (and it is from this standpoint alone that the question is now being dealt with) it is advisable to remove the chill as soon as possible after solidification, although, as previously stated, this is not always done in our own practice. The great trouble about cast iron is not so much the amount of metalloids (or impurities as we generally call them) as that with very slow cooling segregation takes place, and destroys the homogeneity of the metal, and this can be more successfully dealt with and overcome in the methods here described than by any other way the writer knows of. It is not possible to prevent segregation altogether in the case of very heavy sections and get a perfectly homogeneous structure throughout, but it is possible to greatly improve large quantities of castings that are being turned out to-day, solely by studying the heat treatment of the cast iron after it has entered the mould. Incidentally, the writer may state that he believes that it is along these lines that the next great development in the foundry industry will move, *i.e.*, the use of iron or permanent moulds, the object of which will not only be to cheapen production, but to get greatly improved castings by preventing segregation.

In conclusion, the writer does not recommend the use of chills as the great panacea for all a foundryman's troubles, for all practical foundrymen know that there are precautions that must be taken when using them. They must be free from moisture and rust, also of the correct form and thickness, and care must be taken that the runner does not impinge on them when pouring, etc. They might easily become an additon to the foundryman's already numerous troubles, but it may again be emphasised that carefully employed they become a very effective factor in preventing liquid contraction, segregation, and frequently in helping to overcome difficulties that may arise in grading the iron, owing to the great variations in the thickness of numbers of small castings in one heat.

Finally, it will be observed that no reference has been made to the coating of the chills. The writer does not think that there is any special virtue in any of the numerous coatings that are recommended. For chills that are entirely surrounded by metal we use ordinary clay-wash and composition blacking. In cases where only one face is exposed to the metal, we use a mixture of oil and plumbago, and, so far, these have answered the purpose better than any of the patent mixings often recommended. The success of the chill *does not depend* so much on the coating as on the other things referred to, *i.e.*, getting them at the right point and of the correct shape, and removing them at the proper time. These are the things that require the most consideration; coating is more a matter of detail and taste.

Discussion.

Mr. F. Andrew, in opening the discussion, said regarding the use of the feeding rod, this was in many cases ineffective, and its objects were not always clear to the feeder, who often imagined he was there to push the metal down with the rod, as with a rammer, instead of keeping a free passage between the interior of the casting and the feeding head. In the case of castings to stand high pressure, feeding with a rod often increased the evil, and he agreed with Mr. Carrick that the probable cause was separation of graphite. A large riser was probably the best feeder. The objection to the large riser was its removal, but this might be overcome in certain cases by contracting the area suddenly, where it joined the casting, by means of a loam cake, thus making the riser readily detachable without the presence of a long narrow connection, which would certainly solidify before either casting or feeding head. Regarding the opposition from the machine shop to the use of chills, such was not justified, and must result from lack of discretion in their use, coupled with the use of metal, the grain of which was already close enough, so that the use of the chill produced a white iron. Besides the production of a white iron, the use of chills sometimes caused blowholes, due to the steaming mould, condensations occurring on their surface. This might be overcome by coating with some such substance as oil and plumbago. In some cases, steel, manganese, bronze, etc., had displaced cast iron for purposes which could be reclaimed by the use of proper metal and the judicious use of chills. The word "chill" was certainly distasteful, but the correct use of chills to prevent sponginess became simply equalisation of chill, or an attempt to produce solidification in both thick and thin parts at the same time. Failure was often due to lack of a check on the quality of metals so chilled. He would like to ask whether Mr. Carrick in any case cast on a piece with a chill in contact as a guide to the quality of the metal in the casting? Also, the manganese in one of the mixtures appeared very high—was that intentional?

Mr. D. Cordingley said he should like to ask what element was most affected by chills. In higher grade iron he found that chills had a weakening effect. He would also like to ask at what temperature during solidification contraction took place. Then, again, at what temperature would it be advisable to take the casting out? The higher the grade of iron, the more liable it was to chill. It was said that chills grew; when did they grow, early on, or straight away? Perhaps Mr. Carrick would also kindly tell them how many times it was advisable to use a chill. In his opinion the tendency of chills to grow led to the bursting of castings.

Mr. Simkiss did not think the feeding rod would take the porosity out of an ordinary valve; they could not take it out altogether, but they could ease it a little. He once rammed up a ring with chills, and though this was partially successful he did not think porosity was avoided; it was merely driven further in. In the analyses given in the Paper, he thought the silicon was too high; they got better results from a low silicon. The metals really wanted selecting. Did not Mr. Carrick find the cost of chilling somewhat heavy. Chills were not made in a few minutes, and he presumed they made them themselves.

Mr. Carrick said that before replying to the questions individually, he wished to make one general observation, and it was this, that although he used the word "chill," the object he had in view in the present case was not "chilling" at all—they must keep that out of their minds altogether. The object of a chill as he used it was entirely different, it was to accentuate solidification. In the case of car wheels, such as were cast in the States, the whole and sole object was to get a real depth of chill. In reply to Mr. Andrew, when they did certain work for the Admiralty they cast test bars. He employed a test to indicate the quality of the

chill, but the only question was rapid solidification. If he had a casting that had previously been porous or spongy, and he designed a chill to remove that porosity, then the object of the particular chill was accomplished. With regard to the higher manganese he had not given the mixture as a sample mixture, and he did not wish them to take it as such. He was making a lot of small cylinders for gas engines and other appliances, all of which were rather thin, and it was for them the metal was intended. Mr. Cordingley wished to know what element was most affected by chills. The manganese certainly was. The next question asked was—at what temperature did contraction take place? It depended exactly on what was meant; the point varied. He had been referring to liquid contraction, which occurred from the point when the temperature of the metal was at its highest; dropping down from 2,800 to 2,500, or even lower, until, in fact, solidification took place. Chills of the description given had been in use hundreds of times, and were still fulfilling their mission as well as ever. His object, however, was not to produce a chill, but simply to cause solidification at a certain point. He was further asked what brands of iron did he recommend when using chills? This would depend upon the class of work. He had made hundreds of such castings, and had never got a chill unless through some misfortune with the mould. "Had he ever had to vent his chills?" Well, no, but he could quite see the danger that was pointed out.

Mr. Simkiss did not agree with the writer in the use of chills to overcome certain defects discussed. The chemist was the man they should look to.

Mr. Hoogg, in seconding the vote, remarked that it had been his experience that in using the chills several times there was lost a good deal of the benefit got from them while they new.

Mr. A. Harrison (Hon. Secretary), in supporting the vote, said many interesting points had been raised during the afternoon, many that appealed to himself as a chemist, and many that did not so closely appeal to him. Some of the questions he would have liked to answer, though it was not his object in rising, to do that. But undoubtedly "the use of chills to overcome liquid contraction," was an unfortunate way of putting it, because it could not be overcome. They could displace the position of the void; the metal in cooling contracted, and left a hole. Sometimes the hole became filled with carbon, and sometimes it did not. In using the chill they solidified the parts that were seen, and the parts that were not seen remained unfilled. It was not to the practical man that they should look for a remedy, but to the chemist. He did not think, however, there was a chemist to-day, or that there ever would be one, who would prevent liquid contraction. The man who could prevent contraction when a substance cooled might be a physicist, but not a chemist. Something was wanted to keep the hole full, and they needed a practical man to tell them how to do that. At the same time, he believed Mr. Carrick had given them a very good idea how to meet the result of liquid contraction. Where such contraction caused flaws, obvious flaws that could be seen, they could be removed to somewhere else where they could not be seen. No amount of chilling would take away the contraction or the flaws, but it removed them to places where they were not noticeable, somewhere where they were least likely to be seen and cause damage. The very fact of taking a chill out quickly after the metal had set, saved the situation, and an annealing effect was got. In thanking Mr. Carrick for his Paper, he would like to mention that Mr. Hailstone, Secretary of the Birmingham Branch, was doing research work in this subject, and that he had practically reached certain conclusions. He had, however, to verify some of his results.

The resolution having been unanimously carried,

Mr. Carrick, in acknowledging it, said Mr. Simkiss had laid down the law very dogmatically. The matter could be put into a few words. On the one hand, they had the foundry manager, who on being sent for by the employer or machinist, was told that he had got porosity in a certain casting, and that in consequence the casting must be scrapped. Then on the other hand, they had got the remedy; he had demonstrated it; it had been used hundreds of times and was effective. Their friend, however, said it was useless, and advised them to wait until the chemist or the metallurgist came along. Now he could not accept that; though he admitted there was a very wide scope open for the metallurgist and the chemist, he doubted whether they would ever really overcome altogether liquid contraction. Let them adopt the remedy to hand, and at the same time if they could get help from the chemist and the metallurgist, let them do so. Only they should not stand aside until those gentlemen had done something for them. (Applause.)

Practical Notes on Modern Founding.

In the course of a Paper before the Scottish Branch of the British Foundrymen's Association on December 14, Mr. G. Watt said:—Machines have not yet been adapted for the making of the larger castings for marine and other engines, therefore, it is necessary to look for other means of producing this class of work from a standpoint of quality, speed, and labour-saving. To begin with, there are three very important things to be considered: first, the time of the moulders or skilled workers, which means wages; second, the mechanical power and plant, and this has a very large bearing on the first; and third, the fuel consumed, both as to kind and quantity. These three mean everything so far as cost of production is concerned. One is often asked in the West of Scotland, "Do you consider a large marine casting (say a cylinder) made in dry sand as good a casting as if it had been made in loam?" This is a very silly question to ask, for the practical dry-sand moulder has only one answer, "Certainly I do." The method of work is governed very much by what the foreman is—if a loam moulder, the principal work will be done in loam; or the reverse if a dry-sand moulder is foreman. Of course, the adaptability of the shop is also to be considered; for to successfully carry on dry-sand work for large marine and other castings, the plant must be equipped for that purpose, as, for example, with cast-iron pits sunk into the floor. Some, of course, who adopt the principle, prefer boxes stove dried. Up to a certain size this may be all right, but beyond small cylinders the sunk pit has no equal. One advantage in ramming up is that everything is handed downwards, while with boxes material has to be lifted overhead and the moulder has to climb, and of course he has to depend on stove-drying.

The writer admits freely that in dry-sand work, as also in loam work, drying throughly is the success of a good casting, but with the process of hot air the difficulty of drying is reduced to a minimum. The advantages of dry-sand against loam are, first, that it is more quickly moulded, since in getting the mould ready from a pattern, the cores are also being got ready for the mould, the cores being made in core boxes on a floor provided with stoves for drying them. Then, in preparing to core and cast, the core is started to-day and the mould cast to-morrow, no

matter what size the job, at least up to 15 and 16 tons. Then again, there is the clearing of the pit to be ready for a restart. A cylinder cast one day is always out of pit the following day, and the pit is ready for the next morning; and there is no slacking or easing of any parts, the castings being just pulled out and laid down, so far as low-pressure cylinders are concerned; while M.P. cylinders with chests on gratings carrying cores, the castings are broken out and left till cooler for stripping, when the sand from the moulds is wheeled to the mill to be re-ground with a percentage of new sand added to keep up quality for facing moulds. The same applies to bedplates, columns, etc. The advantage must be obvious, for the delay from one piece of work being cast to another being started is reduced to a minimum, and hence allows speedier delivery and better use of the plant. The same applies to the turbine as to the cylinders; they are never longer in the pit than the day following, unless over-heavy.

Reference may now be made to work which of necessity must be made in loam. In the writer's works there is no loam casting pit, for the reason that all the loam work, such as propellers, propeller blades, liners, cylinder covers, pistons, etc., are all cast on the floor or on the bogie or carriage they are moulded on. A liner, for instance, will be cast in the afternoon and lifted off (cope and liner combined) and a new bed prepared the same night, so as to start another the next morning. The same applies to propellers and blades, so far as casting is concerned. The writer has cast a propeller over 11 tons weight on the floor level, with nothing to protect it but the bolts it is bound with. To those who are acquainted with this class of work, the advantage to be gained by this method compared with the old way of ramming up the mould in a pit is obvious; for not only is there in the latter the labour of ramming up to contend with, but also of digging out again, and a very serious loss of floor space by the size of hole to be dug out. By the other method the moulds are cast just as they are moulded on their carriage, and the top plate takes away the casting in the morning ready for starting again.

As regards the power equipment, crane power is the all-important one, and electric cranes are certainly a step in the right direction. They move quickly, and save the time lost by moulders having to wait on cranes. In the matter of comfort in foundries, there is certainly room for great improvement; for under proper conditions men are able to do more work.

Tipton Green Furnaces.

On Saturday, November 30, the Birmingham Branch of the British Foundrymen's Association paid a second visit to the furnaces of Messrs. William Roberts (Tipton), Limited. The occasion of the first visit was in June, 1907, but the local Branch has grown considerably since that time, and were able to muster a party of over sixty for the second visit. The equipment of the furnaces has also been greatly improved, and the management had some features of special interest to show.

The foundrymen were able to make a fairly complete inspection of the plant, Mr. J. H. Head, manager, and Mr. Joseph Bussey, assistant manager, acting as guides and furnishing ample explanations. From the two furnaces about twelve hundred and fiftv tons per week is produced. A third furnace is undergoing relining. The equipment is very comprehensive, especially in respect of siding accommodation, which has been found of the greatest value. But a still more important addition is the new blowing engine, the third of the kind in operation. The air chamber consists of a 100-in. cylinder, while the steam cylinder has a diameter of 50 in., with a piston stroke of 5 ft. Air pressure can be produced varying from 5 lbs. to 8 lbs. per inch, as required. To accommodate this engine a special engine house had to be built.. The next important equipment is an increase of the calcining arrangements, which has enabled the firm to maintain about 14,000, tons in the process of being calcined. About 500 tons of ore are dealt with per day. The waste gases are utilised for the firing of sixteen boilers, and for the heating of seven hot-blast stoves.

At the conclusion of the inspection the visitors were entertained to tea by the Company. In the absence of the Branch-President, a hearty vote of thanks was proposed to the directors and to the management by Mr. G. Gale, who remarked that the visit had been made very instructive by the full explanations of Mr. Head and his assistant.

Mr. Howell, seconding, said they were deeply indebted to their hosts, and he personally had been impressed with the difficulties which must be connected with blast-furnace work.

Mr. G. Hailstone, also supporting the resolution, remarked that what they had seen had impressed him with the rapid strides made by the Company during the last few years. No doubt that was the first visit which many of their members had made to a blast furnace, and looking at the huge amount of material going into that gigantic structure it was marvellous that iron could be so successfully produced. He spoke with praise of the quality of the iron from the furnaces. He had himself obtained hundreds of tons of pig-iron from Messrs. Roberts, but he had never once had to complain of their pig-iron as being either over or under specification. That was sufficient evidence that the works were scientifically managed.

Mr. F. E. Morgan, also supporting the resolution, said that he was very curious to know something about the measurements of the furnace, such as internal diameter, the casing, etc., and he could not help thinking that the blast furnace would make a fine subject for a lecture at one of their meetings. If they could get someone connected with such a firm as that of Messrs. Roberts to come and give them a lecture describing what took place from the reception of the ore until the production of the pig-iron, it would be extremely instructive, and a most useful sequel to that visit.

Mr. J. H. Head, in acknowledging the resolution, referred to the suggetsion that a Paper be given on the blast furnace, dealing with the ore and its conversion into pig. A great deal had been written and said about blast-furnace work, but in blast furnaces there was always something fresh cropping up every day. They never knew from one day to the next whether they would get the iron out of the furnace or lose it through the bottom. When once a blast furnace was in operation it had to be kept going for three to six or seven years. The firm had experienced enormous difficulties owing to the congested state of the railways and the shortage of wagons. Since the coal strike of this year they had had as much as they could do, and, in fact, rather more than they could do, to meet the demand, owing to the great scarcity of pig-iron. Unfortunately, trade in this country ran in cycles. What they really wanted was a good steady run of business. Booms were no good to any of them; they did not last long enough. In conclusion, he remarked that no doubt after their visit the founders would have greater sympathy with the blast-furnaceman. Anyhow, he hoped they would have greater respect for Tipton Green Ironworks. (Applause.)

Making a Cylinder Cap in Loam.

By Sidney G. Smith.

[*All rights reserved.*]

The drawings herewith illustrate the procedure in making in loam the cylinder cap shown in Fig. 1. It will be observed that the internal flange is formed without the aid of a dish, a method which can be conveniently adopted with internal flange cylinders, cutting edges, and caps, when only two

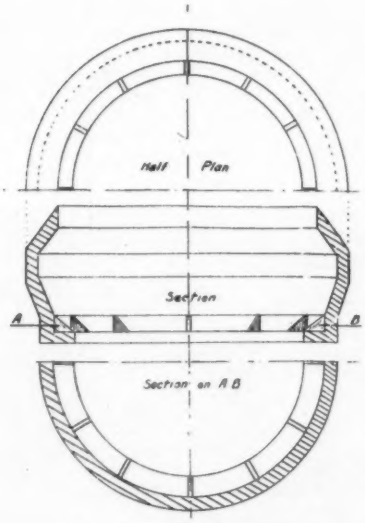


FIG. 1.—CYLINDER CAP.

or three castings are required which do not warrant the expense of making a dish. But in this case, unless the casting is of very large diameter, the cake plate (B, Fig. 2, and Fig. 10), which carries the brickwork of the core, is made for each casting, on account of it being broken for contraction. Fig. 2 shows the sectional assembled mould complete. A (also Fig. 3), is the core-seat ring or plate; a level bed of loam,

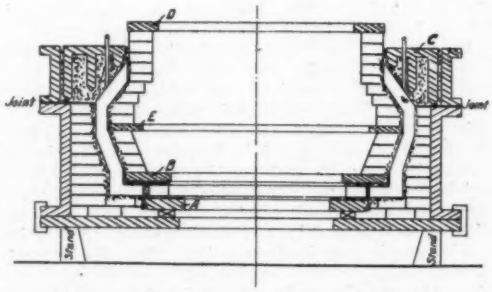


FIG. 2.—SECTION OF ASSEMBLED MOULD.

the thickness of the internal flange, is swept upon this and dried. B (see also Fig. 4) is a cake plate which is swept with a level layer of loam. After being dried, bracket divisions (of which there are 12) are marked off and cut out, and the plate is turned over, rested and centred upon core plate A and the brickwork proceeded with.

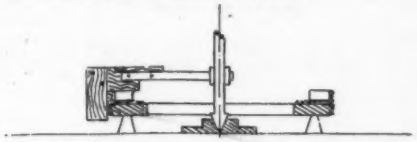


FIG. 3.—CORE-SEAT RING (A, FIG. 2).

Fig. 5 shows the core-board set, and the core section complete. The core is lifted for stoving by three staples case in the core-seat plate. Fig. 6 shows the mould-board set and a section of the brickwork.

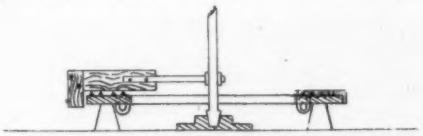


FIG. 4.—CAKE PLATE (B, FIG. 2).

Fig. 7 (C, Fig. 2) shows the board set and a section of the top part of the mould from the joint. A

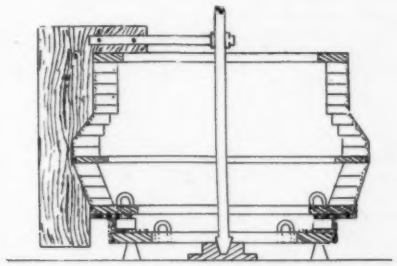


FIG. 5.—CORE BOARD SET AND SECTION OF CORE.

special prodded ring or plate is made to carry this part of the mould.

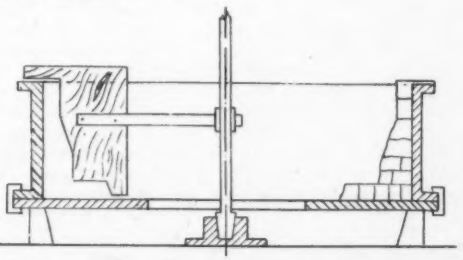


FIG. 6.—MOULD BOARD SET, SHOWING SECTION OF BRICKWORK.

Fig. 8 (A, Fig. 2) shows in plan and section the core-seat plate; Fig. 9 (D, Fig. 2) is the top core

binder; Fig. 10 (B, Fig. 2) is the flange cake plate, showing recesses provided for the brackets; Fig. 11

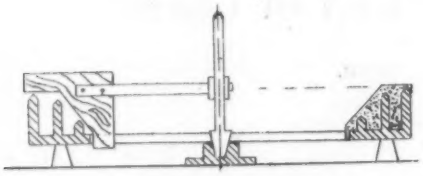


FIG. 7.—BOARD SET FOR MAKING TOP PART OF MOULD ON PLATE C.

(E, Fig. 2) is the middle core binder; and Fig. 12 shows in plan and section the prodded plate C, to

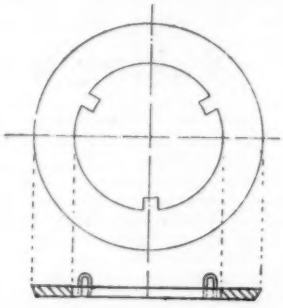


FIG. 8.—CORE-SEAT RING (A, FIG. 2).

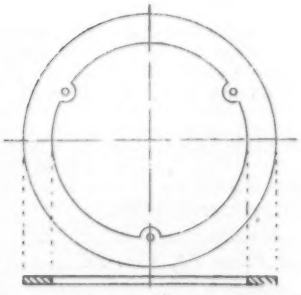


FIG. 9.—TOP CORE BINDER (D, FIG. 2).

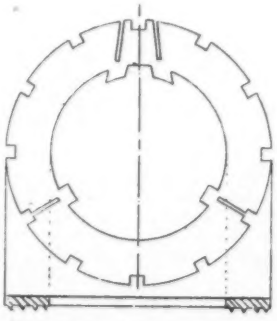


FIG. 10.—FLANGE CAKE PLATE. (B, FIG. 2).

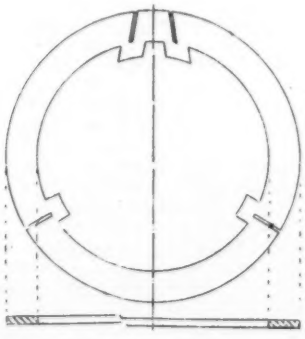


FIG. 11.—MIDDLE CORE BINDER. (E, FIG. 2).

carry the top part of the mould. The gate and riser holes, staples, etc., are shown. The procedure in

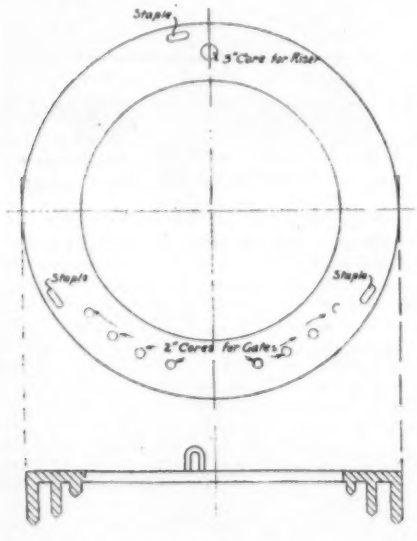


FIG. 12.—PRODDED PLATE (C, FIG. 2) TO CARRY TOP PART OF MOULD.

moulding this job will be readily understood from the drawings.

Rusting of Cast Iron

In a Paper dealing with "The Rusting of Cast Iron, recently presented before the German Foundrymen's Association, Prof. K. Arndt reviewed the extensive literature on the subject of rusting, with special relation to the behaviour of bare iron toward oxidising influences and the question whether high-carbon cast iron or low-carbon mild steel is the more liable to rust. The experiments of Heyn and Bauer have shown that both rust about equally in stagnant water, whilst the cast iron is more powerfully corroded in running water. Moreover, in water charged with carbonic acid, cast iron rusts four times as much, and in 1 per cent. sulphuric acid 100 times as much, as wrought iron. In the author's own experiments the behaviour was noted of cast iron and wrought iron, with and without the natural "skin," in moist air and damp sand. The electrolytic theory of rusting attributes the lower tendency of wrought iron to rust to the presence of fewer particles of graphite, and therefore to a smaller number of centres of electrolytic action, but the author failed to obtain any confirmation of this in the microscopic examination of bare iron, visible rust appearing only on the rougher parts of the surface, and as this roughness is greater in the case of cast iron, owing to the varying hardness of its constituents, so rusting is more apparent than on wrought iron. The fact that, in practice, the casting skin is allowed to remain on pipes and structural pieces of this material, constitutes its advantage.

Foundry Plant and Equipment.

Roller Moulding Machine.

The annexed illustrations show a moulding machine of novel design, which, developed and patented by Messrs. Wilson & Mathiesons, Leeds, is now being manufactured by Messrs. Greenwood & Batley, Leeds. The machine is designed to meet more effectively the requirements of light castings foundries, and has now been in operation for a considerable time with highly satisfactory results. The special feature of the machine lies in the application of a roller motion for ramming the sand. It is claimed that this action of the rollers has a kneading and knitting effect, leaving the sand more uniform in density and at the same time more porous than is possible with any other mechanically-operated process. It would appear, on consideration, that there is something to be said in favour of the maker's claims, for no moulder would think of using a flat-faced rammer, which gives a downward or plastic pressure only; he naturally uses a round-faced ram, which presses the sand off at a tangent in many directions. This last is precisely the effect produced by the corrugated rollers in the machine under notice, as they travel over the sand in the box; thus the principle of hand ramming is applied to machine moulding, which the makers claim results in the cheaper production of thinner and more uniform castings than would be otherwise possible. Dealing with the productive costs, it may be here noted that the machines are independent and self-contained, requiring neither hydraulic or pneumatic auxiliary power.

It is claimed by many that the ordinary pressing machine must give a varying density in the finished mould, because if the configuration of the pattern varies, that part which stands the highest, or comes nearest to the pressing plate, becomes harder than the lower parts of the mould, the reverse effect being produced when the opposite side of the pattern is being pressed. In the machine under notice this disadvantage has been eliminated, as the rollers, which are corrugated on their faces, are mounted and revolve on a flexible shaft, and thus as they travel over the box they are free to rise and fall to suit the configuration of the pattern plate, whilst as only gravity pressure is exerted on the sand, pattern plates and moulding boxes as used for hand ramming may be employed.

The construction of the machine will be readily seen from the illustrations. The front side (Figs. 1 and 2) is arranged to hold a double-sided pattern-plate, which rests easily on four machined faces and is accurately registered by two locating pins. Underneath the pattern plate is fixed a simple heating arrangement, which keeps the pattern aired. The moulding box rests on the pattern plate, and is raised by four adjustable stools, which are carried on a frame underneath the machine, and operated by the crank handle in front. The roller motion will be best seen by reference to Fig. 2. It will be noted that the rollers are mounted on a flexible shaft, which is connected to and operated by movement of the large lever through sprocket wheels and endless chain. The rollers are made of a diameter to suit the particular size of box, the radii from one edge of the gap to the other being equal to the width of the box. The rollers are provided with means of adjustment, so that when traversed forward the top edge of the gap coincides with the front edge of the box and the opposite side of the gap falls just within the outer edge of the box, the rollers thus covering the whole of the sand area.

The rollers, it will be further noted, are built up in series, the number varying with the size of the machine and the length of the box. Between each series of rollers a space is provided to allow the rollers to clear the bars in the box. The mechanism for

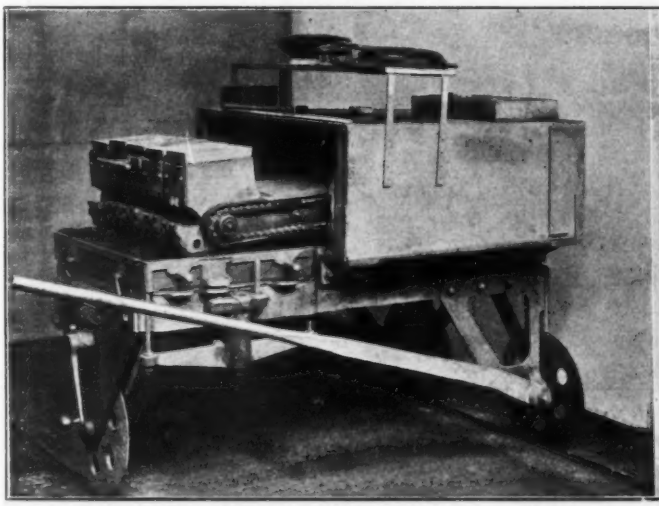


FIG. 1.—ROLLER MOULDING MACHINE; GENERAL VIEW.

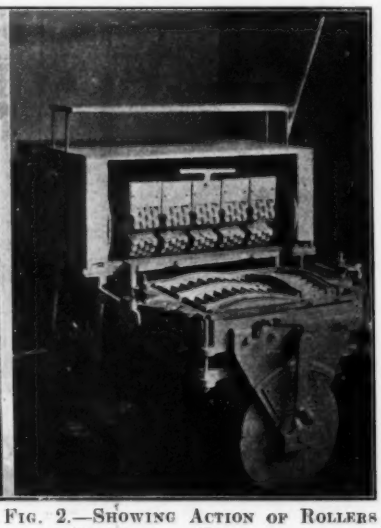


FIG. 2.—SHOWING ACTION OF ROLLERS; PATTERN IN PLACE.

travelling the rollers is clearly shown; the travel is, of course, determined by the size of the box, and controlled by a suitable stop. In operation, a pattern plate is put on the machine and the moulding box, located by the pins, filled with sand, the rollers travelled over the sand face by pulling the propelling lever, more sand added, which is rolled as before, and the box is strickled. The small crank handle, shown on the front of the machine, is now turned, raising the box from the pattern plate, during which movement the plate is slightly rapped. The box is held in the raised position by a spring catch connected to the lifting handle till its removal, when the operations are repeated on succeeding boxes. After a number of moulds have been made, the pattern plate is turned over and the reverse halves of the moulds made. It will be noted that the machine is mounted on runners, and can be travelled along the foundry floor as the moulds are made, thus saving the unnecessary handling.

Figs. 3—5 show a machine intended for deep work, or work having hanging cores, and a series of operations on a typical casting. The machine is the same in general principle as already described, but with the addition of a turnover arrangement. The pattern-plates have trunnion bearings at each end, which rest on bearings formed on swinging arms, pivotted at the rear of the machine. Radial brackets at the side of the machine are provided with notches for holding the pattern plate and box in position, the last-named, secured together by suitable fastenings, are raised by the movement of the left-hand lever, connected to the swinging arms. After filling and rolling as already described, the box and plate are raised together into the top notch of the radial brackets, in which position they are turned over, as shown in Fig. 4; they are then moved into the mid-position, when steadying levers engage with projections at front and rear of the pattern-plate and prevent the latter from oscillating in its bearings.

The four stools are now brought up to the underside of the box and the fastenings securing the box and plate released, when the box is withdrawn from the pattern-plate, the steadying levers falling by gravity into the horizontal position. The pattern-plate is then again raised to the top position to allow of the removal of the mould (Fig. 5), and the plate is lowered into the bottom position ready for the next cycle of operations.

The machines are made in four standard sizes for operation by hand or power, and can be adapted to suit the particular size of boxes employed in the foundry.

FIG. 3.—MOULD WITH SAND ROLLED IN, RAISED FOR TURNING.

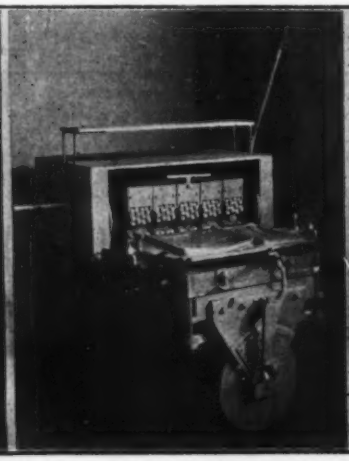


FIG. 4.— MOULD BEING TURNED OVER.

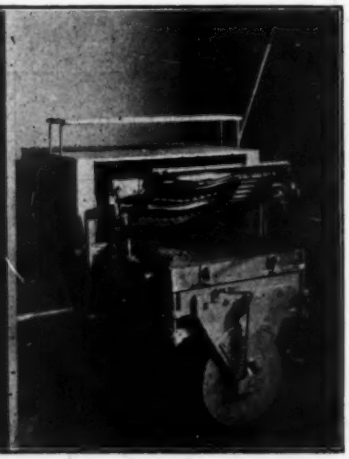


FIG. 5.—PATTERN-PLATE RAISED FOR REMOVAL OF MOULD.

Sand-Mixing Apparatus.

The increasing consideration which founders are giving to the treatment of moulding sands directs attention to the useful sand-mixing machine which has for some time been put on the market by Messrs. Alfred Herbert, Limited, of Coventry. This machine was originally designed by the firm for use in their own foundry after unsuccessful efforts to obtain efficiently mixed sand from other types of machines. With previous machines a great deal of the new sand never reached the moulding floor, as, owing to the imperfect mixing action, it remained in lumps coated with old sand and coal dust, and was detained by the riddle, thus causing loss and waste. With the machine designed by the firm, however, all lumps are crushed and the sand riddles easily, thus saving a great deal of time in moulding. A great economy also results from the fact that the sand does not need to be milled before mixing. The efficiency of the apparatus determined the firm to manufacture it for sale.

The machine consists of a pedestal carrying two vertical spindles rotating at a high speed, one within the other. The spindles are driven in opposite directions by bevel gearing from a pulley on a horizontal shaft. The upper ends of the spindles carry two intermoving cages, the bars of which, passing each other in opposite directions at a great speed, do the mixing and disintegrating. The cages are covered by a dome-shaped casing which directs the mixed sand on to the floor and prevents it from flying about. The centre of the dome carries a hopper, into which the unmixed sand is fed, and from which it drops into the centre of the cages. The hopper can be lifted off for the purpose of cleaning and for removing stones and other hard matter which may be caught by the bars. Sand that contains stones or pieces of iron should be screened before coming to the mixing machine. The machine will deal with all the sand that two men can shovel, and in practice 7 cwt. per minute is a conservative estimate of its capacity.

Jarring and Turn-Over Moulding Machine.

The machine shown in Figs. 1 and 2 combines the principles of jar ramming and turning over. It has been designed by the International Moulding Machine Company, Chicago, Ill., U.S.A., for such work as piston rings and pistons. The machine consists of a main frame or stand, a turn-over frame or pattern carrier and a crank, the function of which with its adjacent parts is to release the mould from the pattern after it has been turned over and to support it in the proper position ready for lifting off. The jarring section consists of two heavy castings, a piston and a table that are cast together and a cylinder. The machine has a valveless control, the action being effected by a groove operating in conjunction with port holes in the cylinder. The plunger is single-acting, the air pressure on one stroke acting against a vacuum.

The trouble caused by subjecting the movable and adjustable parts to the vibration of the jarring section during the ramming of the mould has been avoided by completely disconnecting the plate which rests on the table of the jarring section from the turn-over frame while the flask is being rammed. The machine stand, is provided to support the weight of the mould when it is placed on the receiving table and to automatically raise it to a convenient height for the moulder to lift it off after it has been released from the pattern.

The two sets of stops or bearings, provided to limit the movement of the pattern frame when it is turned over, are so machined as to locate the plane of the pattern at the proper angle to secure a perfect draw. For clamping the bottom board and mould to the turn-over frame, an adjustable flask rod is fitted to the steel shaft on which the turn-over frame revolves. Adjustments are provided to accommodate the machine to the variations in bottom boards and depths of flasks. The machines illustrated are operated by hand in turning over and releasing the pattern, but where the mould is too large to be handled conveniently in this manner, the machine is equipped with air cylinders.

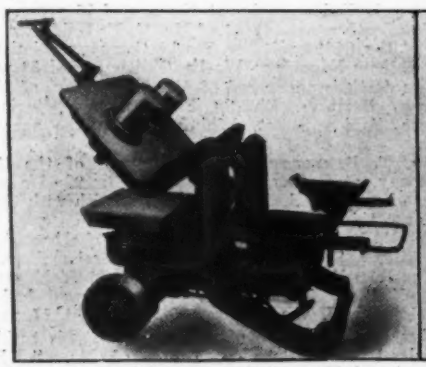


FIG. 1.—JARRING SECTION AND KNOCK-OUT ARM OF COMBINATION MOULDING MACHINE.

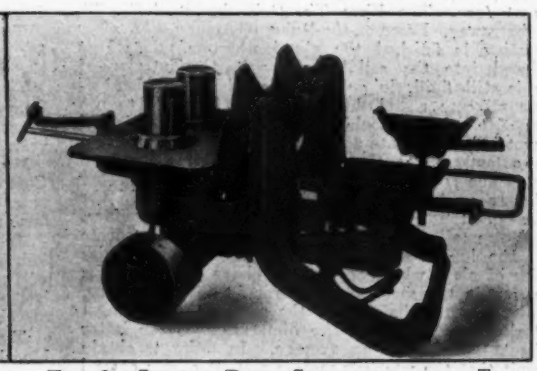


FIG. 2.—JARRING PLATE STATIONED ON THE TABLE OF JARRING SECTION OF COMBINATION MOULDING MACHINE.

locking and releasing mechanism by which this is accomplished consists of a steel sliding lever with rollers fitted to the turn-over frame, a slotted pin which is fastened to the jarring plate and a knock-out arm, shown prominently in Fig. 1. This is so located that when the turn-over frame is being lowered to the position illustrated in Fig. 2 the roller on the sliding lever is engaged by the knock-out arm and drops down into the slot thereof, causing the lever to slide forward and become disengaged from the pin which had previously held the plate and the frame firmly together. In the illustrations the patterns are shown attached to the jarring plate, but in actual use a regular pattern plate is used and this plate is fastened to the jarring plate so that only one set of locking and releasing mechanisms is required for each machine.

A set of tempered extension springs for counterbalancing the weight when turning over is attached to the turn-over frame at one end and to a stationary steel shaft in the rear of the machine at the other. These springs are fitted with eye bolts having right- and left-hand threads and the tension can be rapidly adjusted in accordance with the weight to be turned over. Another set of springs attached at one end to the crank and at the other to the cross-rail of the

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WALTER SOMERS & COMPANY, LIMITED, of Halesowen, near Birmingham, have started an important profit-sharing scheme amongst their employés, who number 700. The articles of the agreement are as follow:—(1) The deposits of not less than 1s. and not more than £1 of the depositor's weekly wages will be received from persons in the employ of the company each week. The amount agreed upon will be kept through the wages sheet. (2) Officials who are paid quarterly will deposit sums of not less than 1s. and not more than £2 per week. The allowance must be handed in at the cashier's office of each department. (3) In the case of employés paid weekly the total amount which they may deposit is £200. In the case of those paid quarterly the total is £400. (4) The board of directors reserve the right of fixing a limit to the total amount which will be received upon these terms. (5) A fixed sum equal to 5 per cent. per annum will be allowed as interest on all deposits. (6) In addition to the fixed rate of interest a bonus will be declared each year equal to half the difference between the fixed rate of 5 per cent. and a dividend payable on the shares of the company. (7) Sums withdrawn will be entitled to only the 5 per cent. interest from March 31 preceding up to the date of the payment. They will, however, be entitled to their proportion of the bonus paid to March 31 preceding. (8) No interest or bonus will be allowed on sums of less than 10s. or in respect of any period less than £1 a month. (9) Deposits will be repaid or may be withdrawn as follows: Up to one-half on seven days' notice; the whole sum on fourteen days' notice. (10) Under special circumstances the company will allow deposits to be withdrawn without notice. Persons leaving the employ of the company will be repaid their deposits on the expiration of fourteen days.

Inventions.

Applications for Patents.

An asterisk indicates that a complete specification accompanies the application. When inventions are communicated the names of the communicators are in brackets.

27,147.*Manufacturing chemically pure steel and cast iron. G. V. Tischenko and H. Plauson.
27,191.*Furnaces. G. W. Morgan.
27,352. Metallurgical heating furnaces. H. Boden.
27,686. Gas or gaseous-fuel heated furnaces. J. King, jun., J. R. Burnett, and Richmond Gas Stove and Meter Company, Limited.
27,825, 27,826, 27,827, 27,828, 27,829, 27,830, 27,831, 27,832, 27,833, 27,834, and 27,835. Aluminium alloys. S. R. Bailey and Navaltum, Limited.
27,978.*Manufacture of steel. F. Thuaud.
28,325. Foundry moulding boxes. H. Rix, W. Moore, W. Stoddart and J. D. Paton.
28,441.*Metallurgical furnaces. J. E. Greenawalt.
28,443.*Furnaces. S. A. M. Weidemann.

Abstract of British Patent Specification recently accepted.

10,117 (1912). *Process for Improving the Properties of Ingot Iron.*—The Firm Th. Goldschmidt A.G., 18, Salkenbergsweg, Essen-on-the-Ruhr, Germany.—If after the casting is finished the aluminothermic mixture is introduced into the solidifying ingot, the interior of which is still fluid, in such manner that the aluminothermic mixture comes down as far as possible to the bottom of the ingot mould, the metal in the interior of the ingot is brought into a bubbling and whirling motion, which extends up to the surface. By this mechanical motion which is aided by the rapid rise of the light slag all blisters or gas bubbles enclosed or retained in the interior of the ingot are forced up to the surface. Furthermore, all the segregations which always separate out in the longitudinal axis of an ingot and likewise particles of slag, which accidentally have come into the ingots, are in the same manner brought to the surface. Immediately after the reaction the contents of the ingot mould shrink according to the dimensions of the latter for about 150 mm. on an average. In order to obtain the result that the whirling motion and its effects extend throughout the ingot, it has proved necessary that the box containing the aluminothermic mixture is pushed down as far as possible to the bottom of the mould. After the reaction is finished and the steel rod by means of which the box has been introduced has been withdrawn, the liquid iron or steel sinks down in the ingot mould. Then the latter is again filled up with liquid steel from the ladle as quickly as possible, the steel being cast from above into the mould in such a manner that the surface equals the level of the crust which has been formed at the surface of the mass. The covers are laid upon the moulds, which then remain on their places till the ingots are perfectly solidified.

THE text has been issued of the Merchandise Marks (No. 2) Bill to amend the law as to trade marks and trade descriptions, which has been presented by Mr. Basil Peto. The measure seeks to provide that all goods bearing inscriptions liable to make purchasers believe that they were manufactured within the British Islands should be marked with the words "British Empire made" if manufactured in any part of the British Empire outside the British Islands, or with the words "Not British" if manufactured outside the British Empire. All goods marked "British Empire made" in accordance with this provision are to be accompanied by a sworn declaration before a commissioner for oaths that the goods were manufactured within the British Empire. The importation of goods not complying with the proposals is to be prohibited, and persons selling any such articles or making false representations as to the place in which the goods were made will be guilty of an offence.

Deaths.

MR. CHARLES VAUGHAN, malleable ironfounder, 80, Legge Street, Birmingham, died recently, at the age of 63.

MR. A. B. WILLWAY, of J. S. Willway & Sons, Limited, engineers, 17, Augustine's Parade, Bristol, died recently.

THE death took place recently of Mr. W. Warner, of Messrs. John Warner & Sons, Phœnix Foundry, George Street, Hanley.

THE death has occurred of Mr. L. H. Bendall, of Messrs. Bendall, Offwood & Son, Lawford Ironworks, Manningtree, Essex.

THE death is announced of Mr. A. Bolton, proprietor of the business of A. Bolton & Company, engineers, of 49, Deansgate, Manchester.

THE death is reported of Mr. J. Lund, engineer and ironfounder, of the Eastbourn Foundry, Cross Hills, via Keighley, at the age of 56 years.

THE death took place on December 22 of Mr. William Penman, a director of Penman & Company, Limited, Caledonian Boiler Works, Glasgow.

THE death is reported of Mr. W. Shepherd, of Messrs. W. Shepherd & Son, Albion Foundry, Longbrook Street, Exeter, at the age of seventy-two years.

MR. L. WILKINSON, of L. Wilkinson & Sons, laundry engineers and ironfounders, of Westwell Street, Great Harwood, died recently, at the age of 75 years.

THE death is announced of Mr. G. E. Holden, a director of the Oldham Boiler Works Company, Limited, of the Oldham Edge Iron Works, Oldham, aged 53 years.

THE death is announced of Mr. T. Ramsay, of Messrs. Ramsay Brothers, Phœnix Foundry and Engineering Works, Albion Street, Whitehaven, at the age of 68 years.

MR. T. BAMFORTH, general manager of the Carron Company, at Carron, died on December 2. He was 72 years of age, and had been connected with with the firm for over thirty years.

MR. F. BEDFORD, who resigned the chairmanship of Wheatley & Smith, Limited, crucible steel makers, etc., of the Russell Works, Kelham Island, Sheffield, on May last, died on November 28. The deceased had been associated with the company for the past 17 years.

THE death occurred on December 2 at his residence, Moorland View, Bramley, Leeds, of Mr. S. Haley, managing director of the firm of Thomas Haley & Company, Limited, Railway Foundry, Bramley, Leeds. Mr. Haley, who was 73 years of age, went to Bramley from Cleckheaton about 1863, and founded the firm of which he was the head.

THE death is reported of Alderman Henry Long, of Worcester, aged 65 years. The deceased gentleman was the late head manager of Messrs. Stringer Brothers, Albion, West Bromwich, and retired to Worcester 25 years ago. He was elected Chamberlain in 1906, and proceeded to the higher offices of Sheriff and Mayor in the following two years, and made an Alderman in 1909.

THE death at Lancaster on December 1 of Mr. George Worsdell removes the oldest representative of a family associated with railway engineering from its earliest beginnings. Mr. Worsdell was born in Preston in 1821. After passing through his father's works, he accompanied his father to Leipzig in 1836, to construct the carriages for the Leipzig and Dresden Railway. In 1838 he took engagements at Euston and New Cross, and also at Swindon, where, for a few months, he was associated with the late Sir Daniel Gooch. A few years later, in 1845, he established the Dallam Forge at Warrington. The business steadily increased, and in 1851 he received the medal of the Great Exhibition "for excellence of Iron and of Railway Plant." In 1857, in consequence of a breakdown in health, he was compelled to relinquish business, and after two years' rest at Workington he took an appointment at the Ashbury Carriage and Plant Works at Openshaw, and became general manager, but he was unable to stand the strain, and for the same reason, having taken over later the management of the Lancaster Wagon Company, he was, in 1872, compelled finally to retire from business life.

Trade Talk.

Messrs. Lodge Brothers & Company have removed to Wrentham Street, Birmingham.

Barlow & Chidlaw, Limited, engineers, of Pendleton, Manchester, have been placed on the War Office list.

The London offices of the Coalbrookdale Company, Limited, have been removed to 1, Berners Street, Oxford Street, W.

Bradley & Turton, Limited, propose carrying out extensive improvements at their Caldwall Foundry, Kidderminster, Worcestershire.

It is stated that the Universal Grinding Wheel Company, Limited, of Sheffield, have arranged to establish extensive works at Stafford.

Mr. E. Holt, trading as James Holt, engineer and machinist, Pilling Street Iron Works, Burnley, Lancs., is shortly paying a dividend.

Considerable damage was caused by fire recently at the works of J. E. Bates & Sons, Limited, brass founders, Temple Street, Wolverhampton.

A fire which broke out at the Wolsingham Steel Works of J. Rogerson & Company, Limited, involved the partial destruction of the gun shop.

The discharge from bankruptcy of Mr. W. Blezard, trading as James Blezard & Sons, iron and brass founders, Guy Foundry, Padiham, has been granted.

Stewarts & Lloyds, Limited, propose erecting additional works at Riddrie, Glasgow. Negotiations have been opened up with the Glasgow Town Council.

Messrs. G. Moore, C. H. Moore, and F. Moore, carrying on business as engineers, at Hinckley, under the style of Moore Brothers, have dissolved partnership.

Mr. P. Hodgson, engineer, carrying on business at the Guide Bridge Ironworks, near Manchester, is paying a first and final dividend of 3s. 3½d. in the £.

Mr. J. W. Saunderson, trading as Saunderson & Son, engineers and brass and iron founders, New Bridge Ironworks, Eastgate, Louth, has been adjudged bankrupt.

The Wombwell Foundry and Engineering Company, Limited, have decided to carry out extensive improvements to their works at Wombwell, near Barnsley.

The new firm of Hacksaws, Limited, who acquired the business of the Sesame Hacksaw Company, have established themselves in business at the Canton Works, West Street, Sheffield.

Loudon Brothers, Limited, Clyde Engineering Works, Johnstone, have appointed as their London representative Mr. John Pickworth Reynolds. The company's offices are at 110, Cannon Street, E.C.

Thompson & Southwick, Limited, are in voluntary liquidation for the purpose of reconstruction. The business will be taken over and continued by the new company of Thompson & Southwick, Limited.

Edwin Cottam & Company, Limited, of the Don Steel Casting & Spring Works, Rotherham, are shortly erecting another steel foundry at Rotherham for the manufacture of steel castings by a new process.

At Barnsley, recently, the Dearne & Dove Steel Works, Worsbro' Dale, now dismantled, were offered for sale by public auction, but the reserve price was not reached, and the property was accordingly withdrawn.

Messrs. H. B. Barnard & Sons, metal merchants, 148½, Fenchurch Street, E.C., and Lambeth, London, S.E., have appointed Messrs. Dobbertin & Company, of Hamburg, as their sole agents in the German Empire.

The estates of the St. John's Foundry Company, Foundry Lane, Perth, and Thomas Russel Barker and Stewart Baxter, both engineers, the individual partners of the firm, were sequestrated on December 17 by the Sheriff of Perthshire, at Perth.

Mr. J. Hinckley, 6, Cobnar Road, Woodseats, Sheffield, has been appointed British agent for Messrs. A. Johnson & Company of Stockholm, Sweden, owners of the Avesta Iron and Steel Works, for pig-iron, iron ore, billets, blooms, ingots, etc.

We understand that the business of the Electric Furnaces and Smelters, Limited, of High Town, Luton, is being taken over by the Thermo-Electric Ore Reduction Corporation, Limited, who propose adding considerably to the capacity of the plant.

A meeting of the Birmingham section of the Institute of Metals was held on December 10, Professor Turner presiding. There was a discussion on the "Treatment of Waste Products from Metal Works," which was introduced by Mr. Spittle.

Mr. G. W. Coxson and Mr. T. R. Townson, lately with Ingram & Kemp, Limited, brassfounders, 209, Newtown Row, Birmingham, have established themselves in business at the Alliance Works, Essington Street, Birmingham, as makers of gas fittings.

The partnership heretofore subsisting between Messrs. D. Anderson, W. S. Parsons, and F. W. Gepp, carrying on business as engineers, at 18 and 20, Farringdon Road, Clerkenwell, London, E.C., under the style of D. Henderson & Company, has been dissolved.

W. V. Waite & Company, Limited, engineers, merchants and agents, Gordon Chambers, 31, Queen Street, Cardiff, have decided to take up more convenient premises, and, consequently, early this year they are removing to the Alpha Works, Taff Wells, Glam.

The partnership formerly subsisting between Mr. W. Fry, of Wellington, Somerset, and others, carrying on business as engineers, etc., at the Reliance Foundry, Wellington, Somerset, under the style of Ford Bros. & Company, has been dissolved. Mr. E. A. Morss has purchased and is now carrying on the business.

Mr. F. Rogers, D.Eng., has now completed his engagement as metallurgical adviser to Sir A. M. Rendel and the late Mr. F. E. Robertson (recently Rendel & Tritton). Dr. Rogers informs us that he has entered into practice as a consulting metallurgist and engineer at Bodega Buildings, High Street, Sheffield.

The members of the Corbyn's Hall Iron and Steel Works, Limited, will meet at 13 & 14, Abchurch Lane, London, E.C., on Monday, January 13, 1913, for the purpose of having an account laid before them showing the manner in which the winding-up has been conducted and the property of the company disposed of.

An interesting address on "The Development of the Iron Trade from Ancient Times up to the Present" was delivered by Mr. D. E. Roberts, M.Inst.C.E., the incoming president, at a meeting of the Bristol, West of England, and South Wales Students' Section of the Institution of Civil Engineers, held at Park Place, Cardiff, recently.

The Central Executive of the Central Ironmoulders' Association, in their report to the members for the quarter ending September 30, state that the membership of the organisation is now 5,817. The total funds at the credit of the Union are £30,244, which is a decrease of £207 when compared with the funds at the end of the previous period.

The partnership heretofore subsisting between Messrs. G. Booth, H. Booth, and J. J. Wood, carrying on business as machinists, at Stable Street, Hollinwood, under the style of George Booth & Sons, has been dissolved. Messrs. H. Booth and J. J. Wood will in future carry on the business under the style of Booth & Wood (late George Booth & Sons).

The Anglo-Greek Magnesite Company, Limited, of 24, Finsbury Square, London, E.C., in order to cope with the increasing demands for Euboean magnesite, have purchased the magnesite mines of Haghia Triti, Alonaki, Kalamaki, and Stavros, Pyli, situate on the island of Eubœa, and hitherto the property of the Société Hellenique des Mines de Magnesite.

At a meeting of the shareholders of the Airdrie Iron Company, Limited, held on 3rd inst., a resolution was passed to the effect that the company could not, by reason of its liabilities, continue its business, and that it was advisable to wind up the same, and accordingly that the company be wound up voluntarily. Mr. William Mackinnon, C.A., 34, West George Street, Glasgow, was appointed liquidator

W. F. Stanley & Company, Limited, manufacturers of surveying, mathematical, drawing and scientific instru-

ments, etc., Great Turnstile, Holborn, London, W.C., inform us that in consequence of the increase in their business, they have been compelled to provide much larger office accommodation, and in future will occupy the whole of the upper part of the premises at 286, High Holborn, where their show rooms have been on the ground floor for some time, retaining the old premises at 4 and 5, Great Turnstile for export only.

TRIBUTE to one of the pioneers of the application of science to metallurgy was paid on December 7 at the annual dinner of the Birmingham Metallurgical Society, when Mr. A. H. Hiorns, for forty years metallurgical instructor at the Midland Institute and the City Technical School, received from past and present students a solid silver salver as a momento to mark his retirement. Sir George Kenrick presided at the dinner, and supporting him were Professor Turner, Dr. Sumpner, Mr. W. Waters Butler, and Alderman Bean, Mayor of Dudley.

AT a meeting of representatives of all branches of engineering in the Swansea district, convened by Mr. R. A. Jones, held recently, under the presidency of Colonel Sinclair, it was decided to establish a Swansea and District Engineering Society. It was suggested that the new society should embrace all classes and grades of engineering, civil, metallurgical, surveying, marine, electrical, mechanical and municipal, as well as colliery managers and works managers. A committee was appointed to draft a constitution.

MR. J. W. HORNE, B.Sc. (Edinburgh), Assoc.Inst.C.E. (until recently chemist and metallurgist to Messrs. Fraser & Chalmers, Limited, Erith and London, and the British High Power Gas Engine Company, Limited, London), has joined the firm of Murphy, Stedman & Company, Limited, as from January 1. Mr. Horne has had a wide experience in the manufacture of pig-irons in Great Britain, and is well acquainted with the local characteristics and properties of the various brands, particularly in connection with foundry practice, and he will join the firm as technical and consulting director. Murphy, Stedman & Company, Limited, who specialise in foundry machinery, plant and requisites, have now removed to larger premises at their showrooms, 180, Gray's Inn Road, London, W.C.

A MEETING was held at Bolton recently to consider a scheme for the reorganising of the Globe Ironworks, belonging to John Musgrave & Sons, Limited, which firm has been in liquidation since April. Mr. W. H. Hoyle, of the firm of Messrs. Barlow & Jones, Limited, Manchester and Bolton, was in the chair. Mr. Newton, of the firm of Messrs. David Smith, Garnett & Company, accountants, Manchester, explained the scheme as far as it is developed. It was announced that the amount promised to carry out the reconstruction scheme had reached £70,000, and that the sum still required, £10,000, would be raised in the course of a few days. A committee, consisting of Messrs. John Harwood, J. P. Haslam, W. H. Hoyle, Thomas Magee and Thomas Scowcroft, was appointed to go through the articles of the association and make the necessary arrangements for the management of the concern.

THE inaugural dinner of the British Engineers' Association was held on December 3 at the Whitehall Rooms of the Hôtel Métropole. Mr. Douglas Vickers presided, and among those present were Sir Walter Hillier, Sir Robert Hadfield, Sir Charles Dudgeon, Sir William Porter, Mr. J. M. Robertson, M.P., Mr. Beilby F. Alston, Mr. G. Jamieson, C.M.G., Mr. Edward Hooper (President of the Institution of Mining and Metallurgy), Mr E. B. Ellington (President of the Institution of Mechanical Engineers), Colonel J. S. Ruston, Mr. R. Wigglesworth, Mr. A. M. Jack, Mr. Herbert Marshall, Mr. John E. Thornycroft, Mr. A. F. Allingham, Mr. W. F. Beardshaw, Mr. P. B. Brown, Mr. W. H. Dixon, Mr. J. F. Melling, Mr. W. H. Thomas, Mr. W. A. Walber, Mr. Christopher James, Mr. Wilfrid Stokes (chairman of the Executive Committee), Mr. B. H. Winder, Mr. E. J. Fox, Mr. Septimus Young, Mr. Lewis Ransome, Mr. H. Allcock, Mr. G. Maurice Gibbins, Mr. R. E. Commans, Mr. Stafford Ransome (Secretary), and Mr. B. Brennan, C.M.G.

As was announced at the autumn meeting of the Institute of Metals, held in London in September last, the annual general meeting of the Institute, which in former years had been held in January, will this year take place in the spring, the dates selected by the Council being March 11 and 12, 1913. By the courtesy of the Institution of Mechanical Engineers, the meeting will again take place at Storey's Gate, Westminster, S.W. In the evening of the first day the fourth annual dinner will take place. Amongst the papers that will be presented will be Dr. G. D. Bengough's Second Report to the Corrosion Committee, in which he will deal with the results obtained from the experimental condenser which has been running continuously at Liverpool since the beginning of April. Three tubes of each composition represented in the plant will be withdrawn in December, cut up longitudinally and subjected to a detailed examination, chemical and physical. The research into the causes of the corrosion of condenser tubes will not be completed for another two and a-half years. As the funds at present in hand will not permit of the research being carried on beyond the end of the present year, the committee earnestly hope that individuals and firms interested in the subject will afford the necessary financial assistance, which should be sent to Mr. G. Shaw Scott, M.Sc., the secretary of the Institute of Metals, Caxton House, Westminster, S.W.

As a result of a suggestion contained in a paper on "The Nomenclature of Alloys," read by Dr. W. Rosenhain, B.A., before the Institute of Metals in January last, a committee, consisting of representatives of the Institute of Metals and allied societies, has been appointed, under the name of the Nomenclature Committee, and will shortly hold its first meeting. The following representatives on this committee have been appointed:—Institute of Metals: Dr. W. Rosenhain (Chairman of Committee), G. A. Boeddicker, Professor H. C. H. Carpenter, Dr. Cecil H. Desch, Engineer Rear-Admiral G. G. Goodwin, G. Hughes, Sir Gerard Muntz, Bart., A. E. Seaton, and Professor T. Turner. Institution of Electrical Engineers: W. Murray Morrison. Institution of Mechanical Engineers: G. Hughes. Institution of Naval Architects: Sir W. E. Smith. Institution of Engineers and Shipbuilders in Scotland: Alexander Cleghorn. North-East Coast Institution of Engineers and Shipbuilders: The Hon. Sir C. A. Parsons. Society of Chemical Industry: Professor W. R. Hodgkinson. It is proposed that this list shall be further extended as may be found desirable. Another new committee has been appointed by the Council for the purpose of assisting the Dominions Royal Commission in their inquiry into the question of the supply of non-ferrous metals and ores in this country. A report dealing with this subject is being prepared by the committee, of which Professor T. Turner, M.Sc., is the honorary secretary, other members being: Messrs. G. A. Boeddicker, W. Murray Morrison, and Leonard Sumner, and Sir Gerard Muntz, Bart.

Alleged Spoilt Castings.

The hearing of an action, brought by the Pelham Foundry Company, Mitchell Street, Sheffield, claiming £82 12s 1d. damages from Mr. Victor Stobie, in respect of certain castings and materials spoilt in the defendant's annealing furnace when he was trading under the style of the Sheffield Annealing Works Company, was concluded at the Sheffield County Court on November 29.

The plaintiffs' case was to the effect that in consequence of faulty work the castings were rendered useless, and of no value to the plaintiffs for the purpose of their business at all, and that it was an express condition of the agreement that the defendant should be liable to the plaintiffs in full in case of faulty work on the part of the defendant or his servants.

For the defence it was admitted that some of the castings were spoilt by over-heating, but it was contended that it was due to the instructions given by the plaintiffs themselves.

Plaintiffs' advocate submitted that the evidence that had been called supported the view put forward by the plaintiffs that they had no responsibility in the matter.

His Honour Judge Benson, in giving a verdict in favour of the plaintiffs, assessed the damage to the castings at £35 8s., and allowed £5 for loss of profit. He, however, allowed defendant a certain amount for scrap value, reducing the damages to £33 10s.

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COLONIES, AND FOREIGN GOVERNMENTS.

THE Cupola.
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Foundries Completely Furnished.

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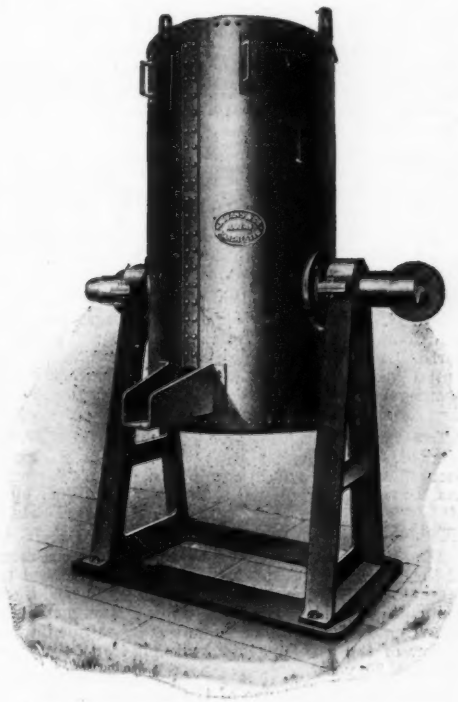
For Emergency Work.



James Evans & Co.,
Britannia Works,
Blackfriars,
MANCHESTER.

Telegrams: "LADLES, MANCHESTER."

Personal.

Mr. E. G. Couzens has been appointed an Inspector of Factories and Workshops.

Mr. R. J. Nichol has been elected a director of R. Hood Haggie & Son, Limited.

Mr. A. W. Tait and Mr. H. F. L. Orcutt have been elected to seats on the board of Fraser & Chalmers, Limited.

Mr. H. W. Atkinson, Mr. F. Bowen, and Mr. F. S. Giller, have been appointed Inspectors of Factories and Workshops.

Mr. Benjamin Talbot, managing director of the Cargo Fleet Iron Company, Limited, has been elected a member of the American Iron and Steel Institute.

Mr. G. A. Boeddicker, of Henry Wiggin & Company, Limited, has been elected a vice-president of the Institute of Metals, in place of Sir Henry Wiggin, Bart.

Mr. T. L. Aveling, of Aveling & Porter, Limited, engineers, brass and ironfounders, of Rochester, Kent, has been elected on the Medway Conservancy Board.

Mr. C. A. Park, M.I.C.E., M.I.M.E., has resigned his positon as managing director to the British Westinghouse Electric and Manufacturing Company, Limited.

The late Mr. Frank Hill, managing director of Richard Hill & Company (1899), Limited, left estate of the gross value of £8,140, of which £1,294 is net personalty.

The late Mr. John Wood, of John Wood & Sons, Limited, Barley Brook Foundry, Wigan, left estate of the gross value of £65,385, of which £64,878 is net personalty.

Mr. R. W. Evans, secretary to the Llanelly Steel Company (1907), Limited, has been appointed to a similar position with the Bynea Steel Works, Limited, of Bynea, near Llanelly.

The late Mr. J. L. Cloudsley, a director of Parkinson and W. & B. Cowan, Limited, engineers and ironfounders, of Birmingham, left estate valued at £60,795 gross, of which £58,483 is net personalty.

Estate of the gross value of £58,754, of which £39,449 is net personalty, has been left by the late Mr. J. Harris, of Apsley House, Wellington Road, Bilston, Staffs., formerly in business at the Britannia Ironworks, Bilston.

Mr. G. Pate has been appointed manager for the Carron Company in succession to the late Mr. Thomas Bamforth, J.P. Mr. Pate has been assistant manager for the past 11 years, and prior to that he was in charge of the commercial section of the company's pig-iron and coal departments for eight years.

The vacancy on the board of John & Edwin Wright, Limited, caused by the death of Mr. W. E. Hipkins, has been filled by the election of Mr. T. A. Taylor, who has been associated with the company for upwards of fifteen years. Mr. Walford H. Turner has been appointed assistant managing director.

Mr. John Crawford, one of the best-known members of the iron trade in Nottingham, has been elected to the presidency of the Nottingham Society of Engineers for the ensuing twelve months. In his inaugural address Mr. Crawford gave his fellow-members an interesting review of the development of the pig-iron output during the last 30 years.

Mr. J. H. Fisher, one of the directors of Wm. Jessop & Sons, Limited, Sheffield, was the guest at a dinner given in his honour at the Royal Automobile Club, London, on December 9, on the eve of his departure for an extended business tour in India. Councillor A. J. Hobson, J.P., the chairman of Wm. Jessop & Sons, Limited, was in the chair.

Probate of the will of the late Lord Furness, of Grantley, has been granted to his son, the present peer, his nephew, Mr. Stephen William Furness, M.P., and Mr. Frederick William Lewis, the executors and trustees named in the will. The estate is sworn provisionally at £1,000,000, but this comprises only a portion of the testator's personal estate and does not include any of his landed properties.

Mr. Bedford McNeill has been selected as president of the Institution of Mining and Metallurgy for the next period, and Mr. Edward T. McCarthy has been chosen as a vice-president. Mr. S. Farrar and Mr. J. H. Cordner-James, vice-presidents, have resigned owing to pressure of business, and Mr. W. R. Feldtmann and Mr. F. W. Harbord will succeed them. Mr. O. J. Steinhart and Prof. John Cadman have been elected on the council to fill the vacancies thus caused.

Sir John Storey Barwick, the deputy-chairman of the Cargo Fleet Iron Company, Limited, not seeing his way clear to succeed the late Lord Furness as chairman, the directors have unanimously elected Mr. John Edwin Rogerson, of Mount Oswald, Durham, as chairman of the board of directors. Mr. Rogerson, who has long taken a leading part in the affairs of the company, is eminently qualified for this position, and will command the same cordial support of his colleagues as the late chairman. Mr. George Short Barwick, of Thimbleby Hall, Northallerton, has been elected to the board to fill the vacancy caused by the death of Lord Furness.

New Companies.

D. Wickham & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers.

Rubel Bronze, Limited.—Capital £200,000 in £1 shares. Registered office: 82, Victoria Street, S.W.

Timson, Bullock & Barker, Limited.—Capital £6,000 in £1 shares, to carry on the business of engineers, etc.

R. O. Evans & Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of metal workers, etc.

Rhineland Manufacturing Company, Limited.—Capital £1,000 in £1 shares, to carry on the business of engineers, etc.

Rodney Engineering Company (Liverpool), Limited.—Capital £600 in £1 shares. Registered office: 5, Baltimore Street, Liverpool.

Fred. Burr & Company, Limited.—Capital £10,000 in £1 shares (3,000 five per cent. cumulative preference), to carry on the business of engineers.

Watson & Sims, Limited.—Capital £5,000 in 400 founders' shares of £5 and 300 ordinary shares of £10, to carry on the business of engineers, etc.

Tubbs & Farey, Limited.—Capital £12,500 in £1 shares (6,250 preferred), to carry on the business of brass and ironfounders, etc. Registered office: 19, Goodge Street, W.

W. & E. Moore, Limited.—Capital £3,000 in £1 shares, to carry on the business of engineers, merchants, etc. Registered office: 23, High Street, Poplar, London, E.

Bennett & Tapley, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers, etc. Registered office: Belvidere Works, Belvidere Road, Southampton.

Stephen Fisher & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of ironfounders, etc. Registered office: Pelham Works, Sylvester Gardens, Sheffield.

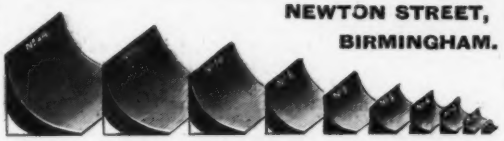
Hutson's, Limited.—Capital £20,000 in £1 shares, to acquire and carry on the business of Hutson & Sons, Limited, engineers, shipbuilders, etc. Registered office: 128, Kelvinhaugh Street, Glasgow.

Tuke & Bell, Limited.—Capital £21,000 in 20,000 participating preference shares of £1 and 20,000 deferred shares of 1s., to carry on the business of engineers. Registered office: 59, Leadenhall Street, E.C.

Charles Ross, Limited.—Capital £20,000 in £1 shares, to take over the business of engineers, manufacturers of scales, weighing machines, and steam and pneumatic hammers, etc., carried on by C. Ross and G. Ross at Heeley Bridge Foundry, Sheffield, and elsewhere, as Charles Ross.

WALTON & CO.

NEWTON STREET,
BIRMINGHAM.



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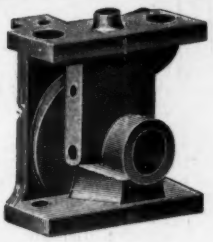
YOU CAN CUT DOWN COSTS ON COMPLICATED SMALL PARTS



¶ To obtain such a part as that illustrated above by ordinary methods of casting would entail an amount of time and money out of all proportion to the profit you should make on it.

¶ Why not secure the extra profit and the certainty of scientific precision that is offered you by using - - -

"Prana" Die-Finished Castings?

Holes, Slots, Teeth, Notches, Screw Threads, etc., are accurately cast — no machining. Send for Booklet F., mentioning this paper, to

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EDMONTON, LONDON, N.

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AS SUPPLIED TO THE
BRITISH
ADMIRALTY DOCKYARDS.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.
We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blowholes and other defects, than we formerly did.

From BOW, McLACHLAN & CO., LTD. (Paisley Foundry), Paisley, Glasgow.

Paisley, 12th March, 1909.

We have yours of 4th inst., and in reply have pleasure in stating that we have been using your Foundry Coke for several years for special purposes with highly satisfactory results.

Elders Collieries, Ltd., Cardiff.

Legal.

Sheffield Trade Marks Action.

In the Chancery Division, recently, before Mr. Justice Swinfen Eady, an important action was commenced relating to the infringement of trade marks used on steel by John H. Andrews & Company, Limited, Toledo Steel Works, Neepsend Lane, Sheffield. Plaintiffs claimed an injunction against Paul Richard Kuehnrich, trading as Darwin & Milner, of 26, Angel Street, Sheffield, to prevent defendant, his servants and agents, from selling, offering for sale, advertising and otherwise disposing of any steel not being plaintiffs' steel, under or by the use of any mark or device consisting of the letters "A B C," or any of them, or by the use of the said letters or any mark representing the plaintiffs' mark in such a way as to be calculated to deceive purchasers.

Mr. Charles Russell, K.C., in opening the case, said that his clients carried on business as steel manufacturers at Sheffield, and they had been established a great number of years. The limited company was formed in 1898, the particular business being the manufacture of tool steel, mining steel, and spring steel. On August 27, 1884, three marks were registered with the Cutlers' Company, viz., A B C in respect of steel goods in class 6. In 1885 another mark was registered—a Sheffield mark, A and B side by side with a double diamond. The plaintiffs had continuously used those marks. As regarded A, B, and A and B marks, the sales thereunder were very extensive, and continued as large as ever. As regarded the C mark, which was used on the higher-priced steel, the sales were extensive up to 1896, but since then the sales had become less, as to some extent it had been superseded by the steel sold under A B, and A and B. Since 1896 orders did not specify C steel, but it was sold as such in reply to orders. With regard to the others, it was sometimes ordered as A and sometimes as B—sometimes it was ordered as quality A or B. On May 17, Mr. Leo Cohen, who was in the employ of the defendant, applied in Germany to register the mark A B C with certain geometrical figures. In January, 1910, Kuehnrich, the defendant under the name of Darwin & Milner, advertised: "Durex 1909 high speed steel and A B C tool steel are used all the world over." The plaintiffs said that was an infringement of their trade mark, and was calculated to deceive.

Mr. A. J. Walter, who appeared for the defendant, said he had to open the case for Mr. Kuehnrich as defendant in the action, as the appellant from the decision of the Cutlers' Company, and as the applicant for the removal of the marks complained of from the register. Counsel said the defendant started to manufacture a non-tempering tool steel. That was made by the Spartan Steel Company, which business he had purchased. Originally this non-tempering steel was called "Unor," and the mark A B C was added. The defendant sent out 21,611 samples up to June 29, 1910, and up to January, 1912, a further 19,000. In no single instance had anybody ever suggested or thought that this mark had anything to do with the plaintiffs, nor until the writ was issued in this action had anybody ever made any complaint that it had to do with the plaintiffs. Circulars bearing the mark had been issued by the defendants all over the world. The last thing the defendant wished was to have his goods identified as any other person's but Darwin & Milner's. The plaintiffs had not called a single witness to prove that anybody had been deceived by the defendant's mark. Counsel went on to say that the jurisdiction of the Cutlers' Company as to trade marks ought not to be allowed to exist. He had always protested against it, and he hoped that the next Trade Marks Act would deal with it.

Mr. Justice Swinfen Eady, in delivering judgment, said he had come to the conclusion that the plaintiffs were entitled to an injunction to restrain the infringement of their registered trade marks, or any of them, and to restrain the defendant from passing off by describing his steel as A.B.C. steel. Plaintiffs would have the costs of the action. Regarding the appeal from the decision of the Cutlers' Company allowing the plaintiffs to register the mark "A.B.C." as an associated mark, his Lordship said the plaintiffs were already the registered owners of the old marks, "A.," "B.," and "C.," separately. He was satisfied that the defendant's use of his "A. B. C." mark down to June 8, 1910, when the plaintiffs applied to register, was not an honest use. It was clear that the defendant's mark so closely resembled the marks of the plaintiffs that it was calculated to deceive, and his Lordship was of opinion that the decision of the Cutlers' Company allowing the registration of plaintiffs' new mark was correct, and that the appeal should be dismissed, with costs.

Trade Secrets.

An interesting action to obtain an injunction and damages was brought at the Birmingham Assizes, recently, by Thos. Holcroft & Sons, Limited, of the Sittingshall Foundry, Sittingshall, near Wolverhampton, against George Thompson, and Joseph & Jesse Siddons, Limited, ironfounders, Hill Top, West Bromwich. Plaintiffs' claim was against Thompson for an injunction to restrain him from making use of certain information acquired in their service, and against the co-defendants to restrain them from using such information. Damages were also claimed against both defendants.

The case for the plaintiffs, as outlined by counsel, was to the effect that Thompson was employed by the plaintiffs as a foreman fitter for a number of years, leaving them to enter the service of Messrs. Siddons. They alleged against Thompson that when he was in their employment and contemplated leaving it, he took the opportunity to copy for his own purposes many of the details which came under his notice as foreman fitter, and that he improperly carried those details to his new employers, Messrs. Siddons, who used them for their own purpose and to the prejudice of Messrs. Holcroft. Thompson had been with the plaintiffs for twenty years. Of course, to some extent (continued counsel) what a rival in trade did was known—what he produced was known, and to a certain extent his methods were known. After Thompson left plaintiffs discovered that Messrs. Siddons were developing methods of manufacture in producing certain articles closely on their (plaintiffs) lines, and they felt sure defendants could not have done that in so short a time unless they had had the advantage of the assistance of their (Messrs. Holcroft's) late workman.

Opening the case for the defence, counsel denied it was on Thompson's initiative that the alterations in various processes of which the plaintiffs complained were made. The milling machines, details of which, it was alleged, were copied from Holcroft's, were ordered from John Holroyd & Company, and the standard machines were adapted by that firm. The first of them was ordered in 1906, and after it arrived no alteration was made to it. Four of these machines were bought before Thompson entered their employ, and after he came four more —reproductions of the first machine ordered—were acquired. They were still in use in the same condition as when delivered by Holroyd & Company. The kettle-moulding machines of which complaint was made were all purchased before Thompson entered the firm's employ. Plimmer, then their foreman fitter, adapted these machines to their work. The firm had also for some years before Thompson's coming experimented with the electric-deposit system of tinning, though it was not completely successful. After Thompson entered their employ, but not in consequence of it, they perfected the process by adopting a large dynamo. To say that such conduct as theirs was illegal, that the employment of a servant who had been employed by a firm engaged in the same sort of business precluded them from developing new methods would be to paralyse commerce and make business stand still.

Before counsel concluded their addresses to the jury plaintiffs' counsel announced that he withdrew his claim for damages, but pressed for an injunction.

The jury returned a verdict in favour of Messrs. Siddons, and for plaintiffs on the claim against Thompson. Judgment was entered accordingly, his Lordship granting an injunction to restrain defendant from using any of the information in question.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.

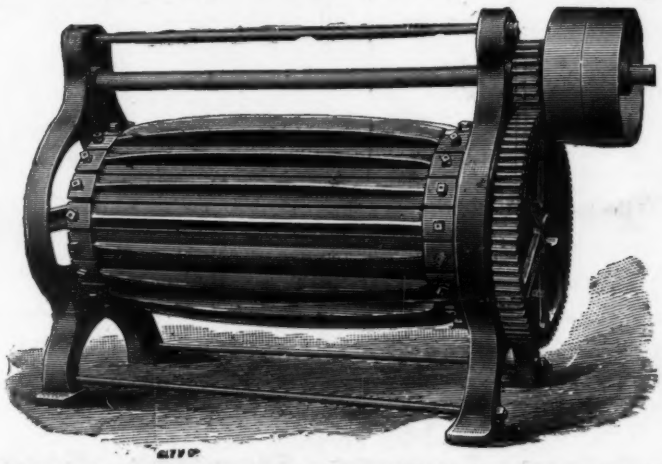
Manufacturers of all

FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years:—

Metals.	End Dec., 1912.	End Dec., 1911.
Iron—Scotch pig warrants ton	..... *73/9	..... *56/6
—Middlesbro' warrants .. ton	..... 67 10½	..... 50 9
—W.C. M/nos Bessemer ... ton	..... 86 0	..... 67 0
—Stock, Scotch ... ons	 1,000	 1,000
Copper—Chili bars G M B ton	..... £77 0 0	..... £63 17 6
—Stock, Europe and afloat tons	 43,241	 57,283
Tin—English ingots ... ton	..... £232 0 0	..... £205 0 0
—Straits ... ... ton	..... £229 15 0	..... £206 10 0
—Stock, London, Holland, U.S.A., and afloat ...tons	 13,697	 16,925
Lead—English pig ... ton	..... £18 10 0	..... £16 2 6
Spelter—Ord. Silesian ... ton	..... £26 7 6	..... £26 15 0
Quicksilver (75lb)... bottle	..... £7 8 6	.... £8 2 6
Antimony—Regulus ... ton	£38 0 0 £40 0 0	£27 10 0 £28 0 0
Aluminium—Ingot ... ton	.....£88 0 0	.....

*Settlement price.

Castings.

In the Cleveland district the following are the nominal rates current for castings:—

	£ s. d.		£ s. d.
Columns (plain)	7 7 6	to	7 12 6
Pipes, 1½ to 2½ in.	6 12 6	to	7 0 0
,, 3 to 4 in.	6 5 0	to	6 7 6
,, 5 to 8 in.	6 0 0	to	6 2 6
,, 10 to 16 in.	6 2 6	to	—
,, 18 to 24 in.	6 2 6	to	—
Chairs	4 14 0	to	4 15 0
Floor plates (open sand)	3 10 0	to	3 12 6

Scrap.

The quotations for scrap, subject to market fluctuations, are as follows: Heavy wrought (mixed), £2 16s. 0d.; light wrought, £1 5s. 0d.; heavy cast, £3 0s. 0d.; all per ton, f.o.b., London. Copper (clean), £69 10s. 0d.; brass (clean), £46 0s. 0d.; lead (usual draft), £16 15s. 0d. Zinc, £20 15s. 0d.; all per ton delivered merchant's yards.

Parliamentary Notes.

Fair Wages at Smethwick.

Mr. C. Duncan asked the Indian Secretary whether W. & T. Avery, Limited, of Smethwick, had any contracts with the Indian Government, and, if so, was the Secretary of State aware that they were not paying the rates of wages recognised in the district as fair?

Mr. H. Baker, who replied, said that the firm held several contracts with the India Office, but the Secretary of State was not aware that the fair wages conditions were not being observed. He would make the necessary inquiries.

Insurance Act Query.

Captain Faber has inquired of Mr. Masterman whether, in view of the fact that many firms employing a large number of hands whose wages are an even number of shillings experience difficulty in adjusting the coins in consequence of the provisions of the National Insurance Act, if he would consider the desirability of minting a new coin of the value of 8d., which could be paid to employees from whom 4d. has to be deducted each week.

Mr. Masterman replies that he has not sufficient evidence that the minting of a new coin of the denomination suggested is necessary or desirable.

BLOFIL
THE
IRON CEMENT
(Quick or slow setting grades)
IS
THE CHEAPEST
AND
MOST RELIABLE
for all purposes.
Unaffected by oil, steam, or water.
Sole manufacturers—
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(DEPT. I)
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Telephone National 1223

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

A REVOLUTION IN THE FOUNDRY.

THERE IS NOTHING LIKE IT.

Proved by the leading firms to be absolutely reliable and holds an impregnable position in the foundry after all others have failed

"SPERMOLIN" (Regd).

Is used by all the leading firms in the making of Cores of Castings for Steam Engines, Turbines, Gas and Oil Engines, Motor Car Cylinders, Pumps of all descriptions, Machine Tools, Radiators, Sectional Boilers, Gas Stoves and Gas Rings, Malleable Iron Castings, Steel, Iron and Aluminium Castings.

FOR FURTHER PARTICULARS WRITE TO:—

The SPERMOLIN Core Co., George Square, HALIFAX.

Or to:— **HALL AND GILLAM, EXCHANGE BUILDINGS, BIRMINGHAM.**

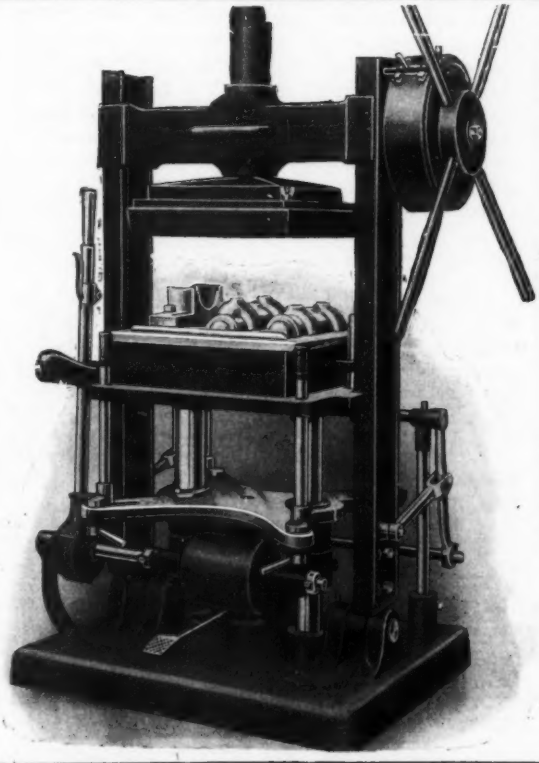

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Plate Moulding with Snap Flasks . .

is used extensively for dealing with light castings in all departments of the foundry trade. It is without question a very rapid method of moulding, and taken in conjunction with the fact that the snap flask does away with moulding boxes it is not surprising that the system is growing in favour. In point of output many power Moulding Machines can show an advantage over plate moulding, but this is over-balanced by the cost of the necessary boxes, the maintenance expenses and the floor space required for storing them.

¶ In our **BOXLESS HYDRAULIC MOULDING MACHINE** we have the snap flask or boxless system combined with a power ramming moulding machine. It is the most complete machine in existence, for it rams both halves of the mould simultaneously, draws the pattern, cuts the runner and gates, closes the mould, and delivers it ready for receiving the metal. ¶ As both halves of the mould are made simultaneously and compressed to an equal extent, much truer and better castings result than when each half is made separately. Correctly located pins and holes in the moulding boxes and pattern frames ensure accurate closing and prevent overshut castings.

¶ The rate of production is such that no man with a plate and a snap flask can possibly compete. 200 moulds a day is quite ordinary and, in some cases, the rate of production with two men amounts to 400 moulds in eight hours.

¶ One firm to whom we have supplied several of these machines is obtaining four times the output they were formerly getting by plate moulding. ¶ Another is getting two and a half times the output, whilst a third is obtaining double the quantity of moulds they were previously getting from pneumatic machines.

¶ The following is some of the work that the machine is doing :—

SEWING MACHINE ARMS. FURNACE BARS. BOILER DOORS AND FITTINGS.
STOVE PLATE CASTINGS. AIR BRICKS. BRACKETS.
COTTON AND SPINNING MACHINE FITTINGS. MANGLE PARTS. COLLIERY TUB WHEELS.
AGRICULTURAL MACHINE FITTINGS LAWN MOWER FITTINGS. ETC., ETC.

The machine will not make any and every casting, but if you will send us sample castings or drawings of your work we will tell you what it will do, or if you would like to see one of our representatives, we will arrange for a visit.

THE QUICKER YOU ACT THE SOONER WILL THE SAVING BEGIN.—WRITE TO-DAY.

With our 15 different types of Moulding Machines we cover the requirements of any foundry.

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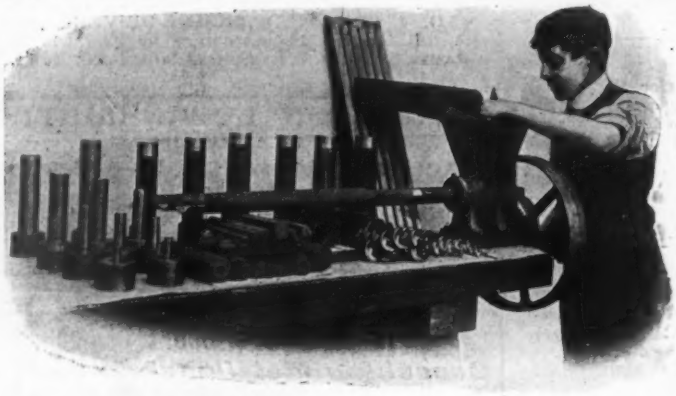

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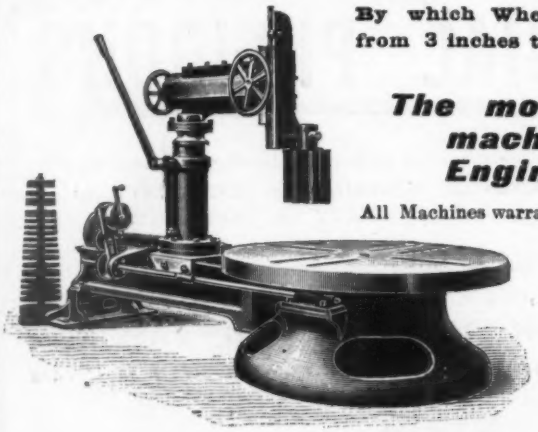

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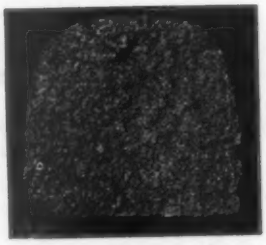
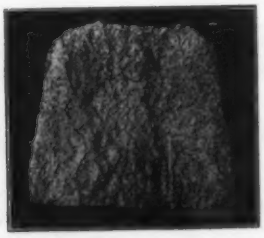
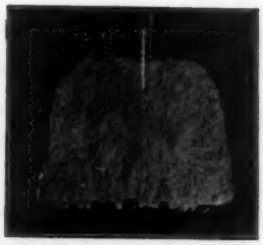

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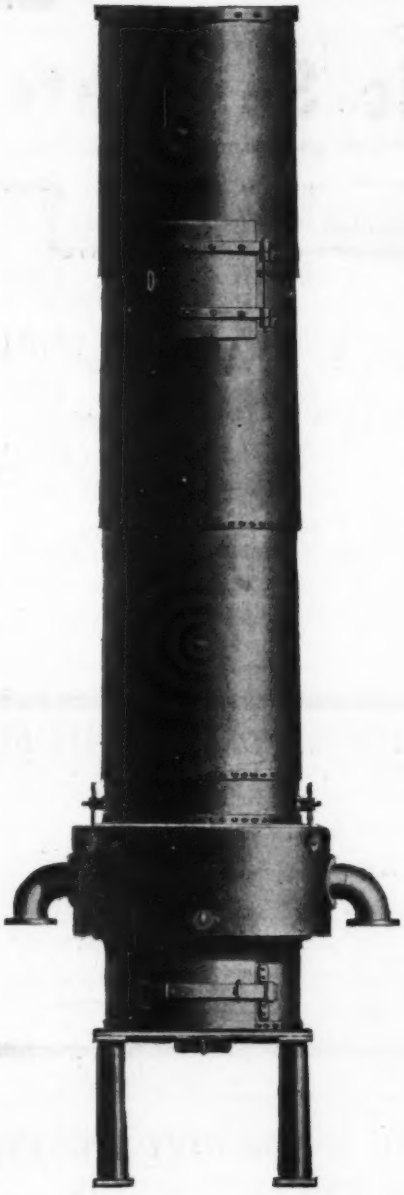

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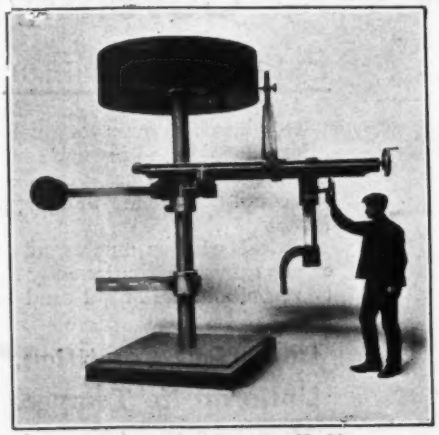

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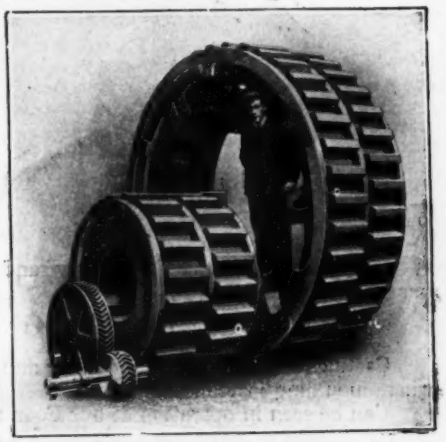

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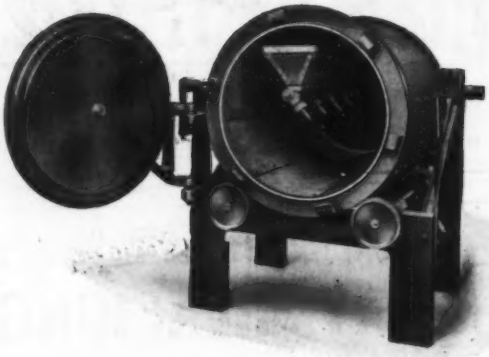

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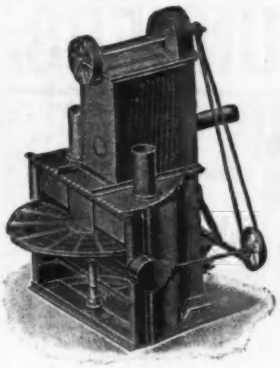

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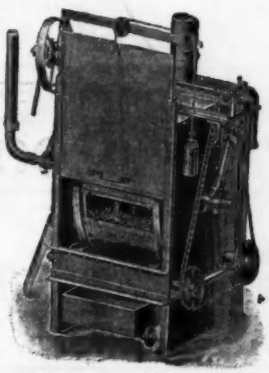

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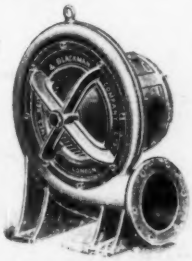
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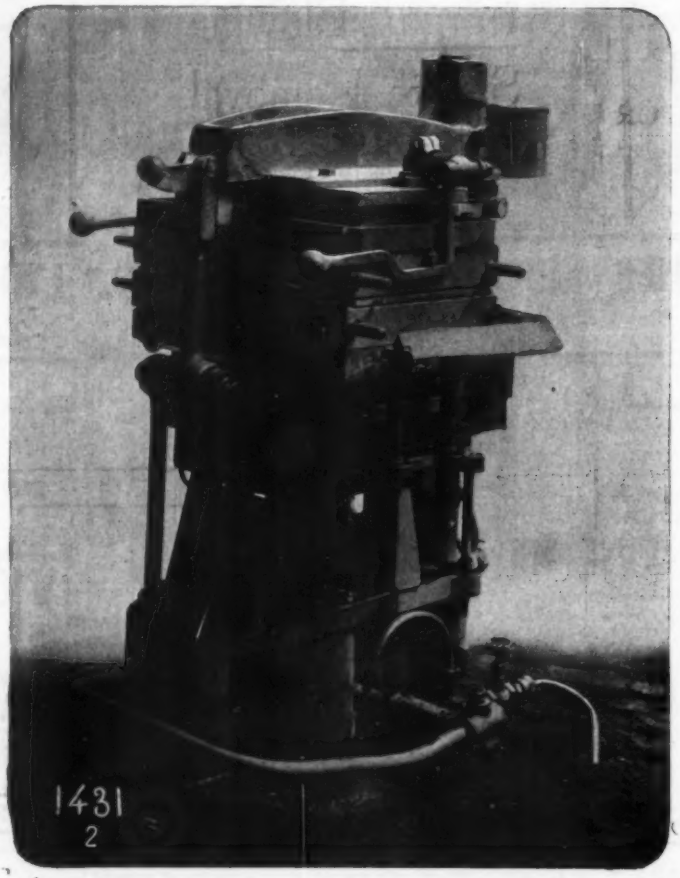

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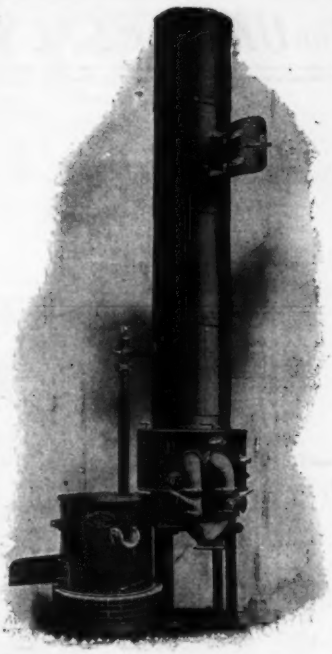

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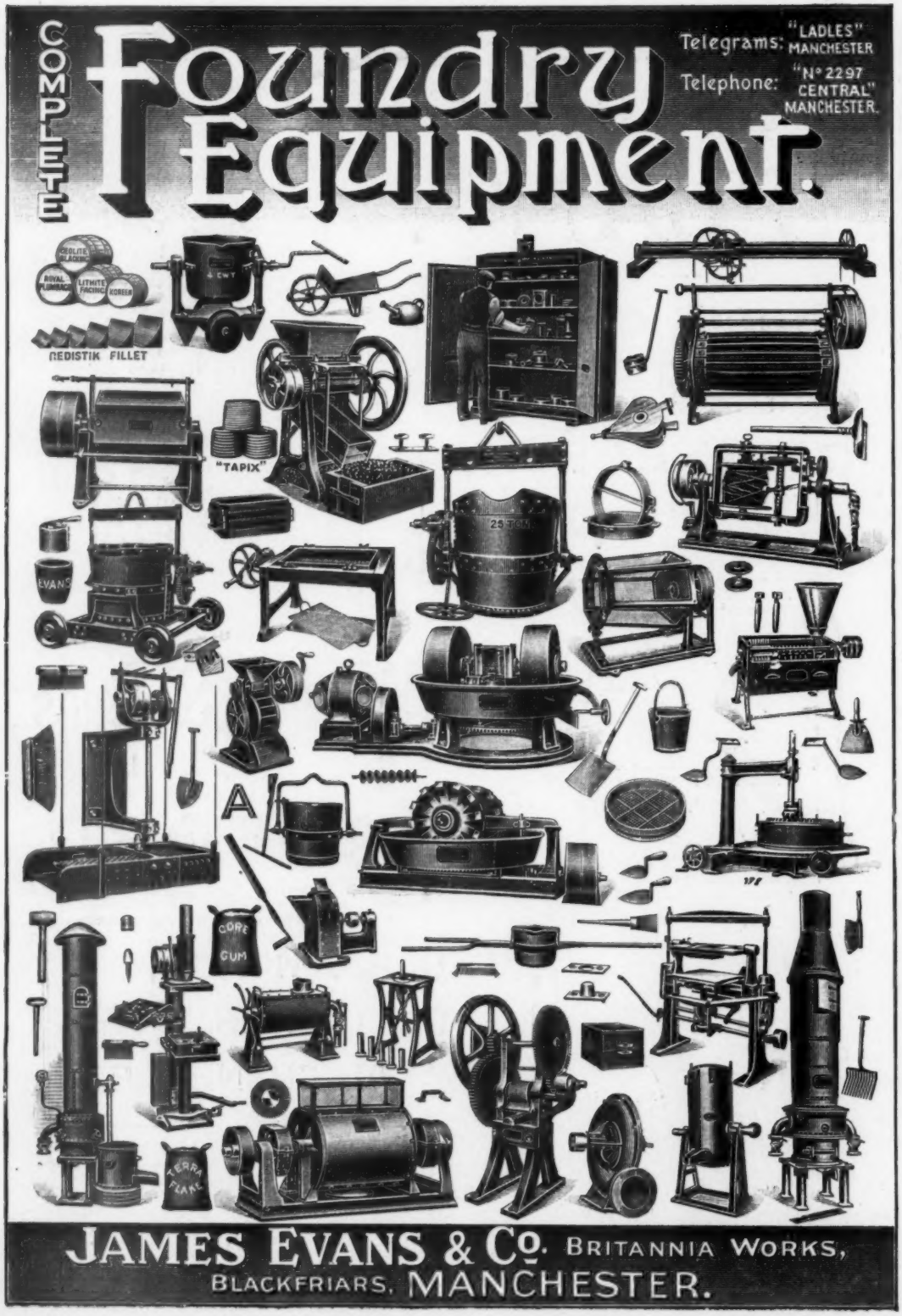
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